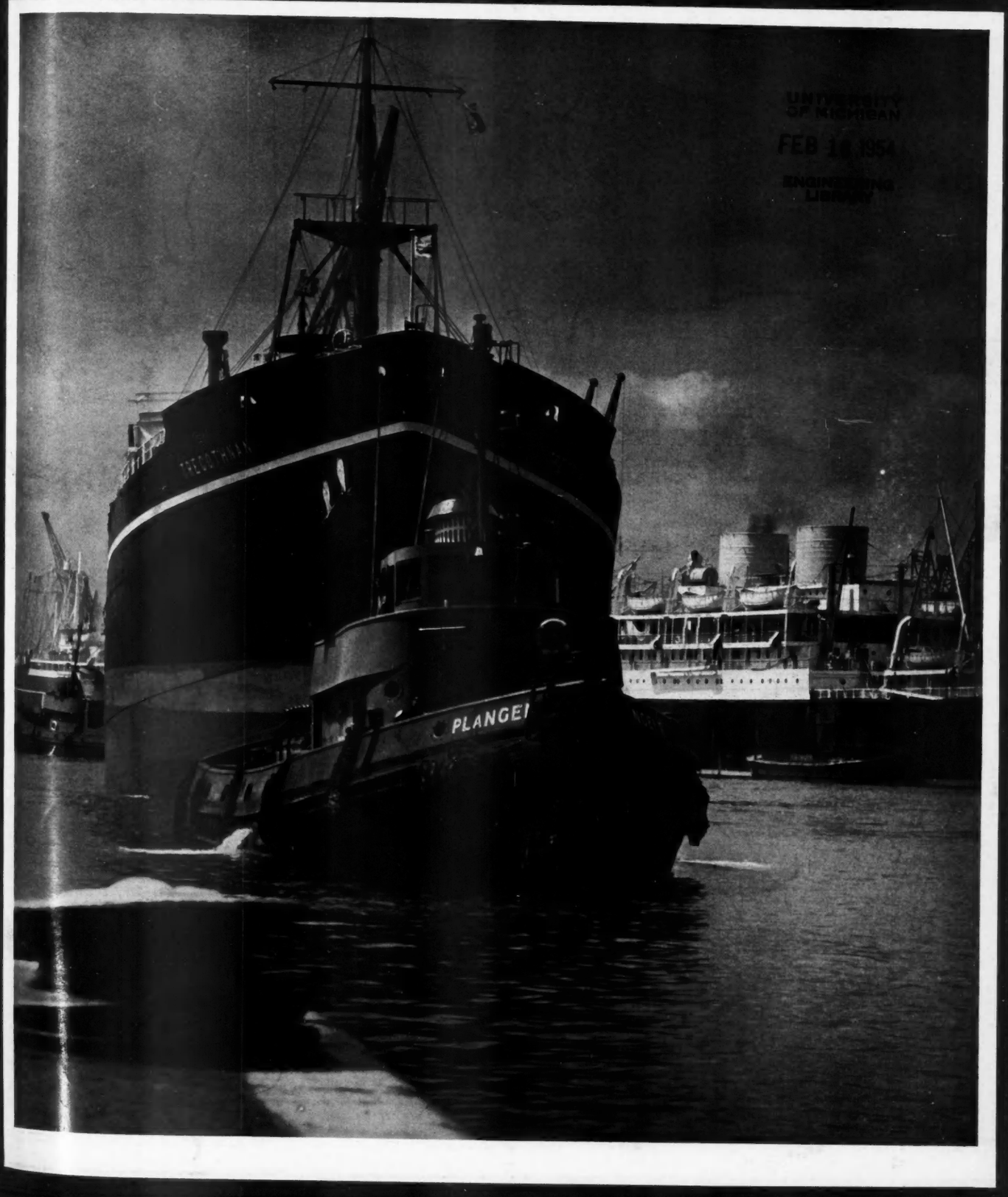


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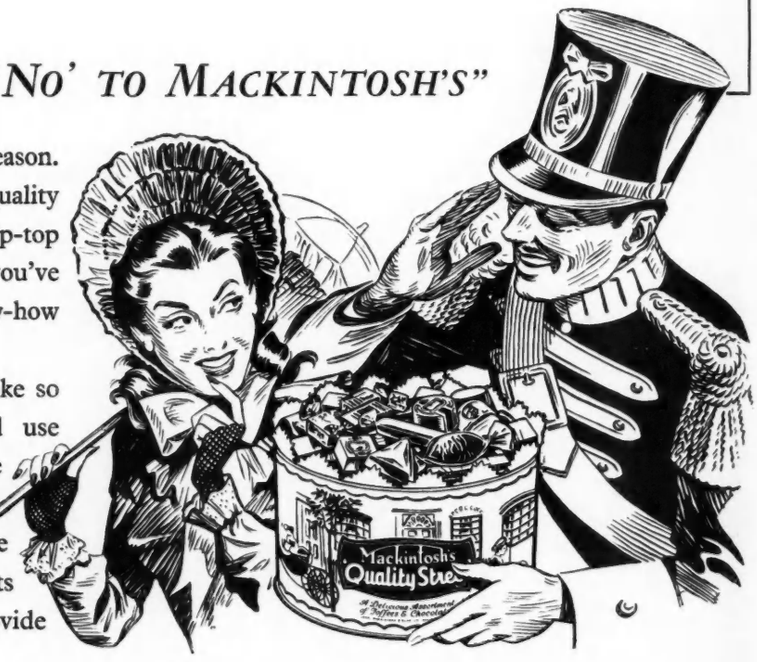
# *What goes on in Quality Street?*

*"NO ONE EVER SAYS 'NO' TO MACKINTOSH'S"*

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*YOU CAN DO A BETTER JOB FOR LESS WITH*

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# ENGINEERING

An Illustrated Weekly Journal

Vol. 177 No. 4592 JANUARY 29, 1954

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# DEADLOCK

IT is a tragic circumstance that the chief form of power a trade union can wield – strike action or a threat of strike action – is one that must inevitably injure, if only temporarily, the very people whose interests it is intended to advance. The community also suffers, and the leaders of industry, who must plan the work of their companies for years ahead, are frustrated by the tactics of those to whom they give employment and prosperity. There is no simple way of altering this situation, and no useful purpose is served by trying to fix the blame. It is the product of centuries of social history and part of the price of democracy.

Turn the pages of engineering journals published since the war and the record of innumerable advances is apparent. Visit the engineering factories of Britain to-day and the liveliness and competence of engineers stand forth. We of the editorial staff of this journal, visiting many works and research establishments in the course of a year, are constantly made aware of the imaginativeness and industry behind the work of engineers. Young men not long finished their training are developing ideas that were little more than dreams before the war, and their elders are daily reaching decisions on questions of policy that can lead to success or failure on a large scale. The value to the nation of all this intellectual and managerial activity is beyond measure. In the material world it is the prime factor, on which all others depend. Yet its value is jeopardised by the corporate action of the very men who, since they build and construct and manufacture, are most intimately acquainted with its quality.

It is well to stress the idea of " corporate action." Most engineers have happy recollections of days in the shops when they acquired a knowledge of (and respect for) the practical skills of engineering. In that sense the chartered civil, mechanical or electrical engineer is in harmony with the man who makes what the engineer has designed. But when that man joins with his fellows in corporate action which destroys the harmony, the engineer feels that the Devil himself has stepped in, disguised as the guardian angle of trade unions.

Current demands for higher wages are singularly ill-timed in the national interest. If anyone doubts this let him refer to the warning Sir Frederick Rebbeck gave on the occasion of the launch of the Iberia at Belfast last week, as reported in this issue. The chairman of Harland and Wolff, Limited, is in touch with commercial trends in a way that few statesmen and no trade-union leaders can ever be. Because the time to design and build ships is measured in years, he can gauge the prospects for 1958. His estimate is far from reassuring. The German people, roused to hard work by their defeat in war, are rapidly restoring their industries to a formidable efficiency. The United States are prospering on the success that breeds success, and every industrialised nation is striving to ensure for itself a proper share in world markets.

Yet it would be wrong to assume that no trade union to-day can present a reasonable case on behalf of its members. It may be that the more astute trade-union leaders are trying to gain concessions before conditions render their case utterly hopeless. They may think that while they have any chance of success they must make the attempt, even to the point of calling a strike. If, as a result of such action, wage increases are gained, then the trade-union leaders must be held responsible for the diminution in orders which would appear to be the inevitable outcome. That is a responsibility which they should hesitate to accept.

When the employers and unions are equally convinced that their attitude is reasonable there is a natural reluctance to submit the dispute to arbitration, since the deadlock can only be broken by a decision which is not agreeable to one of the parties. In these circumstances the machinery for settling the dispute is not practicable. There can, however, be only one correct form of settlement when the arguments of both sides are heard impartially and considered in relation to the general level of wages and the prospects of the industry concerned. Who can best arbitrate and decide the form of settlement? Would it be practicable for representatives of trade unions, other than the one involved, to take part in the arbitration? They would obviously hope to be able to recommend an increase, but they would also know that such a recommendation would, in effect, lower the purchasing power of their own members' wages.

This country has been reasonably fortunate in the incidence of strikes since the war. There has been a welcome change in the outlook of trade-union leaders on such vital subjects as ways and means of increasing productivity – a change more in accord with modern conditions. But there is still room for a whole-hearted drive to advance the prosperity of British industry. The triangle of forces consisting of the unions acting in one direction and scientists and engineers acting in another must become a straight line, so that the resultant force is the sum of the two – a dominant force in the world, free from domestic friction.

# Weekly Survey

## OIL DOCK ON THE SHIP CANAL

On January 19 the new oil dock built for the Manchester Ship Canal Company, Limited, at the entrance to the canal was formally opened. It has been named The Queen Elizabeth II Dock and is described in this issue. It is expected to handle six million tons of crude petroleum a year and its 20-acre basin provides sufficient room for four tankers in the 30,000-ton category to tie up and discharge over 100,000 tons in a few hours. Commenced in 1949, its construction was the outcome of the policy to import petroleum in the crude state so that none of the products of refining is lost to the country, and also of the policy to import petroleum in tankers of a far greater tonnage than was the practice before the war.

The import of petroleum and petroleum products through the Manchester Ship Canal is not new ; it has, in fact, been increasing since the Ship Canal was opened in 1894. But the new dock, combined with the existing facilities at Stanlow, gives the Port of Manchester a capacity for the importation of petroleum of approximately ten million tons a year. In that respect, therefore, it is second only to London.

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## DEVELOPMENTS IN THE GAS INDUSTRY

The quantity of coal carbonised by the gas industry is increasing steadily each year ; during the last financial year it was 27,590,000 tons and the price paid for this fuel was at a rate of £25,000,000 in excess of what it would have been at prices ruling four years ago. Thanks, however, to improvements in existing techniques, the therms per ton of coal carbonised have increased from 71·62 in the year 1950-51 to 73·65 in 1952-53. This increase in thermal efficiency corresponds to an annual saving of 770,000 tons in the quantity of coal carbonised. In the course of an address given recently to the Parliamentary and Scientific Committee of the House of Commons, Colonel Sir Harold Smith, K.B.E., chairman of the Gas Council, said that the increase in efficiency had been obtained by applying closer technical control to unit plants and also by putting into operation schemes of integration which had resulted in the closing down of some of the more inefficient plants. In all, since vesting date, 150 gasworks had been closed and, at the same time, increasing demands for gas had been supplied.

The opening of oil refineries in this country had resulted in the marketing of a considerable quantity of heavy oil residues and consideration was being given to two ways in which this material could be used by the gas industry. It was being utilised for water-gas plants in a manner similar to gas oil, namely, it was subjected to straight thermal decomposition to produce gaseous hydrocarbons for the enrichment of blue water gas made from coke. Alternatively, the heavy oil residues could be used in separate oil-gas plants specially designed for the purpose. In two plants, both of which employed catalytic processes, one in the South Eastern area and the other in the West Midlands area, thermal decomposition was combined with gasification in steam so that the resultant gas was similar in calorific value and composition to normal town gas.

Tail gases from oil refineries could also be used by the gas industry, but on account of the uncertainty regarding the quality and quantity available, no great progress had yet been made in this direction. Gas of this character, however, was being used in the North Western area; it was supplied by Petrochemicals Limited and Lobitos Oilfields Limited. The tail gas from the former source was diluted with producer gas, or water gas, or a blend of both, before it was mixed with the coal-gas streams. The tail gas from Lobitos Oilfields Limited was taken at Ellesmere Port, where it was diluted with producer gas.

Methane was being drained from coal mines and an experimental supply was now being taken from the Haig Colliery, Whitehaven. The gas was extracted by means of boreholes made at a point about 100 yards back from the coal face. The drainage of methane not only provided additional useful gas but reduced the risk of working in the mines.

The latest line of inquiry pursued by the gas industry lay in the possibility of finding natural gas in Great Britain in quantities sufficient to be of commercial value. For many years small quantities had been produced at Heathfield, Sussex, at Cousland, Midlothian, and in the North Riding of Yorkshire. Arrangements, however, had now been made in conjunction with the D'Arcy Exploration Company, Limited, to carry out an extensive field investigation for natural gas over a period of five years at an estimated cost of £1,000,000.

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## EXHAUST FUMES FROM DIESEL VEHICLES

At the present time a great deal is heard about pollution of the atmosphere in large cities. It has been suggested that the more obnoxious and harmful fumes come from the exhaust pipes of motor vehicles. For this reason it is interesting to hear that engineers of the Esso Development Company have been carrying out tests in which an auxiliary fuel is sprayed into the air intakes of Diesel engines to reduce the quantity of smoke discharged from the exhaust. These tests, which were mentioned in the second of two papers presented before a meeting of the Institution of Mechanical Engineers, are referred to elsewhere in this issue. If the limiting smoke density required by regulation in this country is strictly adhered to, it appears that increased horse-power can be obtained by this method of introducing a secondary fuel directly into the air intake.

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## EUROPEAN PRODUCTIVITY AGENCY

The first year's programme of work of the European Productivity Agency, which was set up by the Council of the Organisation for European Economic Co-operation last May, was published on January 21. It is divided into six main sections; economic and legal problems; technical and administrative problems of industry and commerce; human factors of management and labour; applied research and technology; food and agriculture; and information and general services. The special function of the Agency will be to promote the development of production by the progressive modernisation of equipment and techniques, this being one of the main aims of the Organisation itself.

In outlining its programme the Agency point out that the real measure of its success will be the degree to which it induces official and private organisations of all sorts to accept responsibility for a considerable share of activities so far carried out by government-sponsored bodies. It must therefore aim at giving an initial impetus to groups which can show a reasonable chance of developing with fresh sources of support and to making the projects which it operates self-supporting to a maximum degree. In pursuit of these aims the methods of action open to the Agency are the collation of existing and the acquirement of fresh knowledge, the dissemination or exchange of knowledge and the stimulation of action.

The first of these methods will include such activities as working parties, missions, the employment of consultants, the placing of contracts for research and the acquisition of books and documents. The second will involve the organisation of missions of consultants, training courses, conferences and exchanges of workers, as well as the offer of scholarships, the provision of information services and the publication of reports, case studies, directories and periodical bulletins. Exhibitions will also be sponsored. The third method will include recommendations to Governments, consultations with national or international groups and the sponsorship of private associations by competitions and prizes.

Under the heading of industrial engineering the matters it is proposed to examine include the analysis and measurement of work, statistical quality control, simplification, standardisation, materials handling, plant layout and stock control, all of which can give substantial and rapid improvements without great expenditure on equipment. As regards applied research and technology, the task will be to determine how the building up of scientific knowledge can lead to technological improvements. The task of the Agency in this field will be to supplement what is at present being done by existing institutions, to co-ordinate the work and to strengthen liaison between research and industry.

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## MACHINING HIGH-TENSILE STEELS

Solid carbon-dioxide was first produced commercially in this country over 20 years ago. Since then, owing to its many remarkable properties, it has become widely used for a variety of purposes. Because it sublimes continuously – that is, it passes directly from the solid to the vaporous state – and the heat absorbed by it in making this change reduces the temperature of the surrounding atmosphere, it has proved particularly suitable as a refrigerant for cold storage.

Following the successful production in recent years of stronger and tougher metals having increased heat resistance, for use in the gas turbine and other fields of engineering, and the consequent improvement of cutting tools to deal with them, the need for a coolant capable of maintaining these tools at a normal temperature has increased. As carbon-dioxide can also be fed in the form of a liquid to a nozzle, and then allowed to expand to produce a solid "snow" at −109 deg. F., it has been applied to this problem but, until recently, it has not proved entirely suitable. Hitherto, it has been used in much the same way as an ordinary liquid coolant, and the method by which its properties could be most efficiently used escaped attention.

A new technique, which enables these properties to be better employed, known as Ce De Cut, has now been developed by the Carbon Dioxide Company, Limited, in collaboration with the Central Research Department of the Distillers Company, Limited. It marks a considerable advance in this field, and it will be of particular interest to those who are concerned with the working of modern high-strength materials. The process has been adapted to turning, drilling, milling and grinding, and research into its use is continuing. A report on this development is to be found on page 156 of this issue.

## *Letters to the Editor*

### A LEAD FROM MANAGERS

#### Simplification and New Ideas

SIR, In connection with your article headed "The Manpower Situation" which appeared on page 73 in your issue of January 15, may I make a few comments ?

Whether or not Mr. Graham Hutton's estimate of a 10 to 15 per cent. increase in productivity will be achieved depends largely on managers – a fact that cannot be stressed strongly enough. Possibilities are still unlimited in the field of industrial administration. The sole obstruction to trying out new ideas is the human tendency to employ only well established and trusted methods. The esteem for ultra-conservatism has always been extremely strong in this country and, no doubt, because of it, many less obvious but potentially more efficient schemes have been by-passed.

The best method for a particular purpose is the simplest that will do the job, so that as many people as possible are able to grasp and work the method efficiently. The various possible techniques must be explored and a comparison made for each alternative to show the probable effects on performance and the costs involved. Time thus spent in examining various methods can result in considerable financial returns.

At a time when competition from abroad rises at an ever-increasing rate it is extremely urgent to effect the greatest economy in materials and manpower. The key lies in the hands of managers: no one else can have a better perspective.

Yours faithfully,
W. H. MANN.

129, Fellows-road,
Hampstead,
London, N.W.3.
January 23, 1954.

### CALCULATION OF THE THICKNESS OF HIGH-TEMPERATURE STEAM PIPES

SIR, Dr. E. Voce asks, on page 67 of your issue of January 15, on what evidence I base the assertion that thick pipes flow and burst in accordance with the Coulomb-Tresca or Guest criterion of yield.

He can find my answer for pipes of the sizes and material in question in ENGINEERING, vol. 93, page 22 (1912), in which I showed that the tests of Cook and Robertson described in vol. 92, page 786 (1911) are perfectly represented by the formula $p = R \log_e \frac{b}{a}$, where $a$ = inner diameter, $b$ = outer diameter, R = tensile strength of the steel, and $p$ = bursting pressure. Since that date, Professor Michiels, of the v.d. Waals-laboratorium, at Amsterdam, and I, have repeated these tests.

In my book, *Plasticity in Engineering* (Blackie and Son, Limited, 1947) this subject is fully treated. In chapter 13, pages 83-85, it is shown that in some experiments plastic flow starts at a combined tension according to Maxwell 15 per cent. higher, but then the pressure drops. May I recommend him to read also page 156 of my book, dealing with a simple appliance for detecting the drop in shearing stress at plastic flow, and also page 157.

Yours faithfully,
F. VAN ITERSON.

The Hague,
Waalsdorperweg 108,
January 18, 1954.

## *Obituary*

### THE DUKE OF MONTROSE

#### Shipbuilding Interests

In many and diverse fields, the death, on January 19, of the Duke of Montrose will be severely felt, for there can have been few members of the Scottish or English peerage who interested themselves in such a variety of pursuits as he did, or who showed equal keenness and aptitude in mastering their technicalities. His Grace, who was 75 years of age, died at his home at Drymen, Stirlingshire, after only a few days' illness. He was the sixth holder of the dukedom, and succeeded his father, the fifth Duke, in 1925.

The Most Noble Sir James Graham, K.T., etc., who was probably better known in engineering and shipping circles by the title of the Marquess of Graham, which he bore during his father's lifetime, was born on May 1, 1878, and was educated at Eton. Leaving school at the age of 18, he entered the Navy as a volunteer on board the full-rigged steam corvette, H.M.S. Volage, in which he served for 18 months. He then transferred to the merchant service as fifth officer in the Devitt and Moore sail training-ship Hesperus, employed on the Australian run, and in 1899 obtained a Board of Trade master mariner's certificate in sail and steam. His next appointment was as navigator in Lord Brassey's famous yacht Sunbeam, in which he voyaged again to Australia and also to Canada. On completion of this period of qualifying service, he was elected a Younger Brother of Trinity House.

On the outbreak of the Boer War, he rejoined the Navy and went to South Africa with the Naval Brigade, in the cruiser H.M.S. Doris. Returning to the Clyde, he continued to take an active interest in the training of volunteers for the Navy and was appointed to command the Clyde Division of the Royal Naval Volunteer Reserve and served with them in the 1914-18 war.

In 1906, he joined the firm of William Beardmore and Company, interesting himself particularly in the shipbuilding side of their activities, at Dalmuir, and becoming especially prominent as an advocate of gas engines for marine propulsion. Under his direction, the obsolete gunboat Rattler was fitted with a 500-h.p. five-cylinder engine and a Capitaine suction gas plant; the engine anticipated more recent practice in Diesel-engine design in having a frame constructed entirely of plates and angles. It operated on the single-acting four-stroke cycle and ran at 130 r.p.m. The cylinders were 20 in. bore and 24 in. stroke. The operation of the plant was not unsatisfactory, but it was unable to compete successfully with other marine prime-movers and eventually the Rattler became a drill ship for the Clyde Division of the R.N.V.R. The Marquess's next interest was more successful, for it was he who proposed, shortly before the 1914-18 war, that the Lloyd Sabando liner Conte Biancamano, then on the stocks at Dalmuir, should be converted into an aircraft-carrier. This was done, and as H.M.S. Argus she had a long and useful naval career.

On his succession to the dukedom, which coincided in date with the shipbuilding slump between the wars, the Duke of Montrose ceased to take an active part in industrial affairs; but his interest in marine matters continued unabated and found ample outlet in his connection with the Royal National Life-Boat Institution, the Royal Gourock Yacht Club (of which he was at one time Commodore) and the Royal Northern Yacht Club, and the Institution of Naval Architects, of which he had been a vice-president since 1927. He was also president, in 1914-15, of the Junior Institution of Engineers. An amateur astronomer of some note, he devised the Graham coronagraph, for the study of solar eclipses, and had also the distinction of having taken the first cinematograph film of an eclipse of the sun.

### MR. E. J. FOX

#### Manufacture of Cast-Iron Pipes

We note also with regret the death of Mr. Edmund John Fox, which occurred on January 18 at a nursing home in Tunbridge Wells. Mr. Fox, who was for 25 years managing director of the Stanton Ironworks Company, Limited, near Nottingham, was a Derbyshire man and was born on April 21, 1874. He received his education at Rugby School, and having decided upon an industrial career, entered Elmore's Copper Company, Leeds, as an apprentice in January, 1892. In August of that year he became a student at Nottingham Technical College and attended courses in various scientific and engineering subjects. In August, 1893, he went back into industry as a pupil of the Crompton Company, Limited.

In 1901 he took up a position with Willans and Robinson, Limited, Victoria Works, Rugby, as an engineer representative and continued in that capacity for several years. Following this, Mr. Fox was employed by Stewarts and Lloyds, Limited, but left them in 1917 to become managing director of the Stanton Ironworks Company, Limited, near Nottingham. He relinquished that appointment and retired from the board on June 30, 1942. He will always be remembered for the energy he displayed in the development of the manufacture of cast-iron pipes by the spun process.

In 1936 he gave a sum of money to the Institute of British Foundrymen and this was applied to the foundation of the E. J. Fox Gold Medal which is awarded annually for outstanding work in foundry research or the improvement of foundry techniques.

Mr. Fox was chairman of Davy and United Engineering Company, Limited, Sheffield, for a number of years. He served as a director of Crompton Parkinson, Limited, Stewarts and Lloyds, Limited, and other companies. He was elected an associate member of the Institution of Mechanical Engineers in 1901 and transferred to the class of member in 1910. He was elected an honorary life member of the Institute of British Foundrymen in 1938 and an honorary vice-president of the Iron and Steel Institute in 1946.

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*We also regret to record the deaths of the following:*

COLONEL G. E. HOWORTH, O.B.E., M.C., B.Sc. (Manc.), M.I.C.E., at Cults, Aberdeenshire, on January 11. Colonel Howorth, who was in his sixties, returned last year to this country from Kenya, where he had conducted a consulting engineering practice. Prior to this he had been in charge of the building of docks and port works for Balfour Beatty and Company, Limited, in East Africa, and had been the local agent of the Cleveland Bridge and Engineering Company, Limited, responsible for the building of the Lower Zambesi Bridge and the Howrah Bridge, Calcutta. He saw active service with the Royal Engineers from 1914 to 1919 and from 1943-45.

DR. ING. GEORGE V. LOMONOSSOFF, M.I.Mech. E., Lt.-Col., R.E.M.E. (retd.), on January 11, at the age of 45. Dr. Lomonossoff was Chief Inspector of the Montreal Locomotive Works, and son of the late Dr. George V. Lomonossoff, the eminent locomotive engineer.

# ELECTRICITY SUPPLY IN SCOTLAND

## *Formation of New Autonomous Board for Southern Area*

The object of the Electricity Reorganisation (Scotland) Bill, which received a first reading in the House of Commons last week, is to transfer the functions of the Minister of Fuel and Power in relation to electricity supply to the Secretary of State ; and to set up a new public authority – the South of Scotland Electricity Board – which will be responsible for the generation and supply of electricity outside the area of the North of Scotland Hydro-Electric Board. It will mark a further step in the Government's policy of decentralising the administration of nationalised industries and of increasing Scottish control of Scottish affairs.

The new Board, which will be appointed by the Secretary of State for Scotland, will consist of a chairman and eight members. It will assume the existing functions of the British Electricity Authority from the vesting date – April 1, 1955 – and will generally discharge those functions under the same powers as are already exercised by the North of Scotland Hydro-Electric Board.

The two existing Scottish Area Boards will be dissolved and at the same time the responsibility of the Central Authority for approving constructional schemes, prepared by the North of Scotland Hydro-Electric Board, will cease.

The new Board is charged with the duty of preparing a scheme within twelve months of their coming into operation for setting up two executives, one for the eastern and the other for the western part of the area ; and for delegating to them such functions as may be specified, other than those relating to general financial control and control of charges. This scheme will be submitted to the Secretary of State and will require Parliamentary approval.

Provision is made for the transfer of assets and liabilities from the Central Authority to the new Board and for financial settlements, including payments in lieu of rates. A limit of £75 million is imposed on the amount it may borrow in addition to any sums involved in the settlement with the Central Authority. These loans will be guaranteed by the Treasury. Finally, provision is made in the Bill for the settlement of disputes and for the payment of compensation and pensions.

# AIRCRAFT FATIGUE TESTS AT FARNBOROUGH

By invitation of the Ministry of Supply we were able recently to visit Farnborough and see some of the methods adopted there for investigating the problem of fatigue in aircraft in connection with the Ministry's Research and Development programme. The visitors were received by Mr. A. A. Hall, Superintendent of the Royal Aircraft Establishment, and the work was explained by Dr. P. B. Walker, Head of the Structures Department.

### MEASURING GUST ACCELERATIONS

Fatigue, Dr. Walker pointed out, was due mainly to the gusts or " bumps" experienced by aircraft in flight. Individually, the bumps were usually well within the limits of the structural strength of the aircraft, but their continuation over a long period might result in fatigue failure. To prevent such failures it was first necessary to measure the bumps and for this purpose they had devised and developed an integrating accelerometer which not only counted the bumps but also graded them according to their severity. This instrument was described on pages 473 and 506 of our 173rd volume (1952). With it all British air routes have been surveyed for practically every type of British civil aircraft in regular service. Quite recently a more compact instrument operating on the same inertia principle but employing electrical integration, has been devised and can be fitted permanently on any aircraft to record its history in terms of the bumps to which it has been subjected.

As a main safeguard against fatigue failure a limitation on flying life is imposed by the Air Registration Board, the permitted life being calculated from the gust measurements previously mentioned and from the results of tests of specimens of the actual structures. All the main components, especially joints, of all civil aircraft are fatigue tested to destruction and the tests are repeated for at least six specimens of each component. Two Schenck-type machines are used continuously in testing components in the laboratory. These machines superimpose a reciprocating load on a static load the combined effect closely resembling the loading experienced in flight, except that it is much more rapid ; a test of one second's duration on the machine corresponds to about one hour of flight.

### TESTS OF WINGS

In addition to the testing of components, tests of complete wing systems, and even of complete aircraft, are carried out at Farnborough. In one method used, the wings are caused to vibrate naturally, no weights or springs being added. Sixty identical Meteor tailplanes have been tested to destruction by this method. The tests, however, did not concern the Meteor aircraft itself, the tailplane being regarded as a small-scale wing and loaded accordingly. In some of these tests the wing was enclosed in an insulating casing cooled with solid $CO_2$ to represent the temperature conditions existing at an altitude of 40,000 ft. Wings of the York aircraft, with a span of 113 ft., have also been tested by the natural-vibration method.

Another method, which is rather preferable for testing wings of large span, was shown in operation during the visit, as applied to the wings of an early prototype Comet aircraft, which, it was clearly stated, was not representative of the aircraft in operational service. The accompanying illustration shows this test in progress. It is known as the " slow-loading " method, the load being applied by means of reciprocating hydraulic rams at the rate of ten strokes per minute. Four rams are fitted under each wing along the line of the spar, the load being distributed by short beams made up from rolled-steel sections. We understand that the amplitude of the movement of the wing tip in these tests is $15 \pm 5$ inches, and the test will be continued indefinitely until the wings are damaged beyond repair; one minute in this test, it may be noted, corresponds to about one hour of flight. Recording extensometers are fitted to certain parts of the wing structure, so that the resulting stresses can be determined.

### CRASH OF COMET AIRCRAFT NEAR CALCUTTA

Another interesting and important feature of the work at Farnborough is the investigation of aircraft accidents. It will be remembered that a Comet aircraft crashed shortly after taking off from Calcutta in May, 1953, with fatal results to all on board. After a formal inquiry in India, parts of the aircraft, collected over an area of many square miles, were sent to Farnborough, where they were laid out on the floor of a special hangar, as nearly as possible in their correct relative positions. The position of every part as it fell on to the ground was plotted on a map, from which it has been possible to deduce the order in which the parts broke away. Scratches, dents and paint marks on the broken parts provided further clues to the sequence of failure. The fire which gutted the main wreckage rendered the task more difficult, although some information, additional to that provided by the dents and scratches, was derived from blistered paint, burned surfaces and smoke marks. As a result of this reconstruction and analysis, it has been possible to dismiss lightning and explosion as causes of the accident. Fire, it has been shown, followed and was the result of the structural failure, and the sequence of failure has been established as follows: first one tail plane failed, then the other, the tail plane failures being followed shortly afterwards by the failure of the two wings one after the other. The investigation is being continued in an endeavour to ascertain the actual cause of these events; no evidence of structural weakness in the aircraft has been found. It is considered therefore either that some event occurred which led to a very abnormal condition of flight, or that it encountered weather which would have broken any aeroplane. The technical and general public of the greater part of the world, we feel certain, are waiting anxiously for the success of the investigators in their endeavours to establish the fundamental cause of this disaster, as well as of one equally distressing which another Comet aircraft encountered as recently as January 10, over the Mediterranean, near the island of Elba, shortly after taking off from Rome.

**Slow-loading bending test on the wing of an early Comet aircraft. A reconstruction of the probable sequence of failure of the Comet which crashed near Calcutta has also been undertaken at Farnborough.**

## PERSONAL

MR. L. H. SHORT, M.C., M.I.E.E., M.Inst.T., has been appointed general export manager to the English Electric Co. Ltd., in succession to MR. H S. ASPINALL, who retired on December 31, 1953.

DR. W. B. WHITNEY, M.I.C.E., M.I.E.E., has retired from the British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorkins-road, Leatherhead, Surrey, but is continuing his connection in as part-time capacity.

MR. J. H. R. NIXON, M.I.Mech.E., M.I.E.E., has been elected chairman of the East Midlands Branch of the Institution of Mechanical Engineers.

The board of Newton, Chambers & Co., Ltd., Thorncliffe, near Sheffield, have appointed three assistant managing directors, each with special responsibilities: MR. P. J. C. BOVILL, for the chemicals branch; MR. S. C. TYRRELL, for the excavator branch; and MR. K. E. WALKER, for the engineering branch. MR. R. F. A. SAMPSON, a local director, has been given special responsibility for the company's London interests.

MR. R. B. HILL has been appointed manager, cable sales department, W. T. Henley's Telegraph Works Co. Ltd. MR. W. M. BAXTER is to be chief assistant manager of this department; he has been succeeded by MR. N. B. FROST as manager, export cable sales division.

MR. J. E. SUNDERLAND, A.C.A., has been made director and general manager of Enfield Cables Ltd., Victoria House, Southampton-row, London, W.C.1. MR. M. J. SMITH, O.B.E., B.Sc. (Eng.), D.F.H. (Hons.), A.M.I.E.E., has been appointed technical director of the company.

MR. B. E. LEESON has been appointed home sales manager (plant), Johnson and Phillips Ltd., Charlton, London, S.E.7. MR. C. W. CAWTE, B.Sc. (Eng.), A.M.I.E.E., has been made home sales manager (cables) and MR. D. S. BARWELL has joined Mr. F. C. Morris, the export manager, as sales promotion manager (export).

MR. A. E. UNDERWOOD, executive director of the Plessey Co. Ltd., Ilford, Essex, has been appointed a director of Plessey International Ltd.

In succession to MR. W. L. JAMES, who has been elected chairman of the parent company, Mellor Bromley & Co. Ltd., Leicester, MR. G. A. HANNAH, M.I.Mech.E., has been appointed managing director, of Pegson Ltd., Coalville.

MAJOR-GENERAL W. D. A. WILLIAMS, C.B., C.B.E., director of port emergency planning, Ministry of Transport, is to succeed SIR REGINALD ROBINS as commissioner for transport, East Africa High Commission.

MR. A. P. WICKENS, chief engineer, Armament Design Establishment, Fort Halstead, Ministry of Supply, is to join the service of Vickers-Armstrongs Ltd., on March 1, as manager, industrial tractors, Scotswood Works. He becomes a special director of the firm from that date.

MR. M. ARNET ROBINSON has been appointed a member of the Ports Efficiency Committee in succession to MAJOR ROLAND THORNTON, M.C., J.P., who has resigned on health grounds.

Follsain-Wycliffe Foundries Ltd. announce the appointment of two technical representatives: For Scotland, MR. W. MACFARLANE, 134, St. Vincent-street, Glasgow, C.2; and for Northern Ireland and Eire, MR. J. LUKE, 17, Adelaide street, Belfast.

COMMANDER (E) A. H. ROBINSON, R.N.V.R. (ret.), has been appointed London branch manager, Associated British Oil Engines (Marine) Ltd. MR. K. SCHWARZ, B.Sc., representative of the firm in London for the past two years is returning to the head office, Ashton-under-Lyne, on the staff of the sales director.

MR. L. G. T. FARMER has been appointed assistant managing director and MR. ALLAN BOTWOOD, sales director, of the Rover Co. Ltd.

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## BUSINESS CHANGES

The address of the ROYAL STATISTICAL SOCIETY is now 21, Bentick-street, London, W.1.

SAML. DENISON AND SON LTD., Hunslet Foundry, Leeds, 10, have opened a Midlands office, at the White House, 111, New-street, Birmingham, 2. (Telephone: Midlands 3931.) The manager is MR. B. A. LEWIS.

Licence agreements have been made between HENRY SIMON LTD., Stockport, and the F.X. HOOPER CO. INC., Cranarm, Maryland, U.S.A., for the manufacture and sale of Hooper corrugated-container machinery throughout the world, and also with the J. H. MAYHEW Co., Excelsior, Minnesota, U.S.A., for the manufacture and sale of the Porter partition assembler, on a similar basis.

HOLMAN BROTHERS LTD. are moving their London office from Broad-street House to 44, Brook-street, W.1. (Telephone: HYDe Park 9444), on February 6.

THOS. FIRTH AND JOHN BROWN LTD., Atlas Works, Sheffield, 4, have removed their Cardiff office to 46, Park-place. (Telephone: Cardiff 27922, remains unaltered.)

HEAD, WRIGHTSON & CO. LTD., Thornaby-on-Tees, are opening a branch office at 7, The Side, Newcastle-upon-Tyne, 1. Mr. F. C. Wake is in charge.

RAGOSINE OIL CO. LTD., Ibex House, Minories, London, E.C.3, have formed a fully-owned subsidiary company, under the style of ROCOL LTD., to deal with the sales of some of their specialty lubricants and other products.

THE BRUSH ELECTRICAL ENGINEERING CO., LTD., Loughborough, have opened a new branch office to serve East Anglia at 4-5, Lloyd's Chambers, Lloyd's-avenue, Ipswich (Telephone: Ipswich 2749). The area manager is MR. G. M. INGRAM.

# SCIENTISTS AND ENGINEERS IN WAR

The positions of the engineer and of the scientist in time of war were surveyed in two contrasting papers delivered in London on successive days during last week. The first, "The Engineer's Task in Future Wars," by Major-General G. N. Tuck, C.B., Engineer-in-Chief, War Office, was given at the Institution of Civil Engineers on Tuesday, January 19; on the following day, at the Royal United Service Institution, Whitehall, Dr. O. H. Wansbrough-Jones, C.B., Chief Scientist, Ministry of Supply, read his paper "Science in War." Although these two papers had the common theme of preparation for war, they differed markedly in scope. The second paper was concerned in the broadest possible way with the mobilisation of science, and therefore of scientists, to assist the armed Services in the event of war. General Tuck's paper, and particularly the ensuing discussion, was far more restricted, being concerned primarily with the assistance the practising civil engineer – using the term in its original sense – could give in the training of the regular sapper officer.

Dr. Wansbrough-Jones began his paper by outlining the system which at present existed for bringing science to the aid of the Services. The arrangement was one which had developed largely during the last war when each of the Departments concerned had brought into being – if it had not already existed – a scientific team which was available to assist the Department at all levels from the top downwards.

The necessity for the scientist to be broadly educated outside his particular specialist subject was emphasised by Dr. Wansbrough-Jones, and in relation to the work to be done for the Services he acknowledged the value to the young scientist of time spent – while on National Service – gaining an insight into Service problems. Serving officers benefited considerably from attending special short courses in science, usually held at the College of Military Science, Shrivenham.

### SHORTAGE OF TECHNICIANS

The prevailing weakness in our preparations for a scientific war was, according to the speaker, the general shortage of technicians able to undertake the production, maintenance and repair of the equipment which would be used.

In justifying the research being undertaken by Government sponsored departments, Dr. Wansbrough-Jones pointed to the cost of present-day work; it was this cost which placed the work outside the scope of the universities or industry. As an example, he quoted the instance of modern nuclear-physics stations which might conceivably require a power input of 250,000 h.p., costing, say, £1,000 per hour, without allowing for depreciation.

The objective of the Services to-day was defined by Dr. Wansbrough-Jones as the preparation of a strong defence in depth. In response to a questioner, he afterwards put this depth at 200 miles. The purpose of this deep defence was to give the necessary resilience to absorb the weight of the attack and to give room for re-deployment prior to counter-attack. The formation of this defensive pattern was dependent upon the continued establishment of the army and the navy and also on early detection by radar or other means of approaching attack, supported by immediate action by fighter aircraft. The speaker defined the probable position of fighters in future wars by suggesting that they would serve the same complementary function in relation to guided weapons as did anti-aircraft to fighters during the last war. The further development of guided weapons was said to be a problem in scientific planning rather than one of scientific research.

Dr. Wansbrough-Jones ended his lecture by referring to the modification brought about by the advent of nuclear weapons. He intimated that he expected their use to bring about a significant change in the sizes of the forces employed and he believed that a far greater degree of manoeuvrability than at present existed would have to be developed. With this greater manoeuvrability it would be necessary to bring into being a centralised high command which would act with the speed, in respect of detailed movements, now associated with field commands.

### THE ENGINEER'S TASK

Returning to the paper given at the Institution of Civil Engineers, General Tuck took as his text, when presenting his paper, a quotation from Sir William Halcrow's foreword to the Institution's publication "The Civil Engineer in War." Sir William had written "(the papers) . . . give evidence of the close collaboration that existed between the regular and temporary members of the Services, and it is to be hoped that this collaboration will continue no less strongly in times of peace." This collaboration could be most valuable, suggested General Tuck, if it took the form of assisting in the training of the regular officers of the Corps of Royal Engineers.

At the present time this training was divided into a number of succeeding periods alternating between basic military training, class work, laboratory and some field experience, which led to the officer reaching a level roughly equivalent to that of a university degree or to Sections A and B of the Institution examination. Indeed, it was these public examinations that were used to assess his progress. This period of education was followed by period spent with field units gaining further experience. The duration of his training, including the last-mentioned field experience, occupied between four and five years. Thereafter followed a period of about two years' training in which the civilian engineer could be of greater assistance to the Service: the officer spent two periods of training, first with a public-works contractor and secondly with consulting engineers, so becoming eligible to take Section C of the Institution's examinations. Upon the standard of training given during this period, depended the degree of efficiency which would be achieved by the Corps.

## MULTIPLE-UNIT ELECTRIC ROLLING STOCK

### *Manchester-Glossop Service*

Successful preliminary trial runs have recently taken place between Godley Junction and Glossop, both direct and via Hadfield, with the first unit of multiple-unit stock for the Manchester-Glossop electric service. This service will be introduced about the middle of the present year and will be provided by eight three-car trains, each consisting of a motor coach, trailer and driving tractor. These vehicles have been built by the Metropolitan-Cammell Carriage and Wagon Co., Ltd., Birmingham, 8, the electrical equipment being supplied by the General Electric Co. Ltd., Kingsway, London, W.C.2.

Each motor coach carries four axle-hung nose-suspended self-ventilated motors with an individual output of 185 h.p. on full field and 210 h.p. on weak field at the one-hour rating. They are arranged in pairs in series and the two pairs on each coach can be connected either in series or in parallel. Control is effected by electro-pneumatic contactor equipment. There is accommodation for 174 seated passengers on a three-car train. The coach bodies are of all-steel construction and there are two pairs of electro-pneumatically operated sliding doors.

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## CONNECTING SWEDEN AND DENMARK

### *Proposed Bridge and Tunnel Roadway*

Proposals have been submitted to the Governments of Sweden and Denmark by three Swedish and three Danish contracting firms for a roadway, partly on a bridge, partly in tunnel, to connect the two countries across the intervening Sound. The roadway, which would connect Malmö in Sweden to Copenhagen, would include a bridge four miles long from Malmö to Saltholmen Island and an under-water tunnel 1¾ miles long from the Island to the Danish side of the Sound. The bridge would include a 1,000-ft. span having a clearance of about 150 ft. The project, which would cost about Kr.350 million (£24,100,000), would be sponsored by three banks of each country with Government guarantees.

The road is being planned to have a capacity of between 10 and 15 million motor vehicles per annum and would be operated as a toll road by the contractors for a period of 60 years, after which it would pass into the ownership of the two Governments. The contractors supporting the project are the Swedish firms of A. B. Armerad Betong, A. B. Contractor and A. B. Skånska Cement and the Danish firms of Christiani Nielsen, Højgaard and Schultz, and Kierulff and Saxlid. It is estimated that planning and design would occupy about two years and that the constructional period would amount to about five years.

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## IRON AND STEEL SCRAP

### Order affecting Acquisition

The Minister of Supply has issued an order affecting the acquisition and certain prices of iron and steel scrap. The Order limits the need for a licence to acquire iron and steel scrap to persons engaged in the smelting of iron ore, the production of steel, and the casting of iron or steel. The Order also removes tungsten-steel scrap from price control and amends the instruction for calculating maximum prices where delivery is effected otherwise than by the British Transport Commission or licensed road hauliers. The Order, the Iron and Steel Scrap (Amendment No. 2) Order, 1954, I.S. 1954, No. 50, came into operation on January 21,

# LAUNCH OF P. & O. LINER "IBERIA"

## SISTER SHIP TO THE "ARCADIA"

The twin-screw passenger and cargo liner Iberia, which is being constructed by Harland and Wolff, Limited, for the Australian services of the Peninsular and Oriental Steam Navigation Company, was launched on Thursday, January 22, from the builders' Musgrave Yard at Belfast. The launching ceremony was performed by Lady McGrigor, the wife of Admiral of the Fleet Sir Rhoderick McGrigor, First Sea Lord of the Admiralty. An unusual feature in the case of a merchant ship, though it has long been customary with warships, was the short religious service, conducted by the Rev. J. H. Carson, of Westbourne Presbyterian Church, Belfast, which preceded the naming of the vessel by Lady McGrigor. The Iberia is a sister ship to the Arcadia, built and engined by John Brown and Company, Limited, Clydebank, which is now undergoing trials, and is to sail from the Thames on her maiden voyage early in February.

The Iberia has a length overall of 718 ft. 9 in. and between perpendiculars, 668 ft. ; a moulded breadth of 90 ft. 6 in. and an overall breadth, at the promenade and "A" decks, of 93 ft. ; and a moulded depth, to "C" deck, of 49 ft. 9 in. The gross tonnage is approximately 29,500. She has a curved and rounded stem and a cruiser stern, and, when completed, will have two masts and a single funnel of special design, to discharge the smoke clear of the superstructure. There are four complete steel decks ; two partial decks forward and aft of the machinery spaces ; and, in the superstructure, the bridge deck, promenade deck, boat deck, and "A" deck. The hull is divided into eleven compartments by ten watertight bulkheads. Fresh water, feed water, ballast and oil fuel are carried in the continuous double bottom.

The propelling machinery, supplied by the builders, consists of two sets of Parsons turbines, each comprising a high-pressure, an intermediate-pressure and a low-pressure turbine, geared to the propeller shafts and taking steam at 530 lb. per square inch pressure and superheated to 850 deg. F. from three oil-fired Foster Wheeler water-tube boilers of the controlled-superheat type. Each boiler has an economiser and a Howden-Ljungstrom regenerative air-preheater. The condensate from the main turbines will pass through a Weir regenerative feed-heating system before being returned to the boilers. Electric power for the auxiliaries, etc., will be provided by three turbo-generators, each of 1,200 kW capacity, delivering direct current at 225volts. A further three turbo-generators, of similar output capacity, will supply direct current for the hotel services.

Accommodation will be provided for 674 first-class passengers and 733 tourist-class. An innovation in the first-class accommodation is the provision, in the observation lounge at the forward end of the boat deck, of a chart table, gyro-compass repeater, and other navigational instruments for the information and interest of the passengers.

### SIR F. REBBECK'S COMMENTS ON SHIPBUILDING ORDERS

Sir Frederick Rebbeck, K.B.E., chairman and managing director of Harland and Wolff, Limited, presided at the luncheon which followed the launch, and, in the course of the speech in which he proposed the toast of "The T.S.S. Iberia and the Peninsular and Oriental Steam Navigation Company," commented forcibly on certain views recently expressed in Parliament by the First Lord of the Admiralty, Mr. J. P. L. Thomas, M.P., about the future prospects of the British shipbuilding industry.

He had been accused, said Sir Frederick, of being a pessimist in this respect. He admitted to being "an enthusiastic pessimist, always trying to cover up his undying optimism" ; but, he pointed out, it was not correct to assess the prospects of the industry solely on the orders that they had immediately on their books. The new orders were not coming in at a rate to replace those that were being completed, and cancellations, in the past twelve months, had been sufficient to represent a full year's output for a fair-sized yard. Moreover, foreign competition was growing rapidly in intensity. For 24 years, up to 1950, Harland and Wolff, Limited, had had the largest output in the world ; but in 1951-52 they had been displaced from that position by a Swedish shipyard, and in 1952-53, their output had been surpassed by two Swedish yards, one German, and one American. They had enough work in hand, Sir Frederick continued, to ensure a good output in 1954 ; but the design departments ought to be working on the drawings of the ships that would be required in 1958, whereas, in fact, new orders were practically unobtainable at the present time. On the Continent, on the other hand, the work could be done more cheaply, more quickly and equally well. There was strong Continental Competition in repair work also, and recently he had had to decline a repair contract, for a ship that Harland and Wolff had built, and send the necessary spare parts to a Continental yard, because he could not guarantee to keep the desired delivery date.

Sir William Currie, chairman of the P. & O. Company, who responded, supported Sir Frederick Rebbeck's appraisal of the situation and mentioned that recent inquiries by his company for a 10,000-ton cargo vessel showed that it could be obtained on the Continent for about 10 per cent. less than in the United Kingdom, and with an assurance of delivery in twelve months.

## TRADE FAIR AT BAGHDAD

### *Market for British Goods*

The Federation of British Industries has accepted the invitation of H.M. Government to organise a Trade Fair, which will be held in Baghdad from Monday, October 25, to Monday, November 8. Such a fair is particularly opportune at the present time, since the major part of the revenue now being obtained from oil royalties in Iraq is to be devoted to large scale projects, such as irrigation schemes, the carrying out of which will necessitate the provision of engineering plant. In addition, the employment given by such schemes should increase the demand for consumer goods of all classes.

The Fair will occupy some 1,000,000 sq. ft. about five minutes walk from the centre of Baghdad. It will be an " outdoor " event, no buildings being erected, except for administration, catering or storage purposes. Arrangements are, however, being made to provide covered areas for many of the exhibits, largely as a protection against the sun. Considerable space will be available for the display of engineering equipment on a site occupying some 39,000 sq. ft. In addition, another 32,000 sq. ft. will be available for motor vehicles and 15,000 sq. ft. for cycles, for which there is a considerable local demand. An interesting feature will be an area occupied by earth-moving machinery and other contractors' plant.

The Fair is being handled by a recently incorporated company – British Overseas Fairs, Limited, 21, Tothill-street, London, S.W.1 – of which Mr. Leslie Gamage is chairman and Mr. D. A. Lamb head of the organising staff.

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## EXHIBITION ON FIRE RESEARCH

An exhibition dealing with the work of the Fire Research Station, Elstree, Hertfordshire, will be on view at the Royal Institute of British Architects, 66, Portland-place, London, W.1, from February 10 to 26. The exhibition has been prepared by the Joint Fire Research Organisation, which is sponsored by the Department of Scientific and Industrial Research and the Fire Offices Committee.

A recent line of approach in fire-research practice has been the development at the Station of satisfactory methods of carrying out research into the spread of fire and flames by the use of models. Previously, full-scale tests had been necessary and, owing to the cost of these, the number of tests that could be made was very limited. Much work has been accomplished lately on the fire-resistance of prestressed concrete.

The exhibition will be open on weekdays from 10 a.m. to 7 p.m., with the exception of Saturdays, when it will close at 5 p.m. There will be no charge for admission.

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## EXHIBITIONS OF INDUSTRIAL ELECTRICAL EQUIPMENT

The Midlands Electricity Board are to hold two exhibitions of industrial electrical equipment at their showrooms, 247, Chester-street, Aston, Birmingham, 6. The first, which will be open from February 15 to 26, will show industrial applications of ultra-violet light, and will be staged in co-operation with Hanovia Ltd., Slough. The second exhibition will be of commercial and industrial refrigeration equipment, and will be open from March 22 to April 2.

# FORTHCOMING EXHIBITIONS AND CONFERENCES

*This list appears in the last issue of each month. Organisers are invited to send to the Editor particulars of forthcoming events.*

BIRMINGHAM CLOCK AND WATCH EXHIBITION. Fri., Oct. 30, last, to Sun., Feb. 28, at the Birmingham Museum of Science and Industry, Newhall-street, Birmingham, 3. See also our issue of November 6, 1953, page 605 *ante*.

WRIGHT AERONAUTICAL EXHIBITION. Thurs., Dec. 17, last, to mid-March, at the Science Museum, South Kensington, London, S.W.7. Tel. KENsington 6371. See also our issue of December 11, 1953, page 756 *ante*.

INTERNATIONAL EXHIBITION ON LOW-COST HOUSING. Wed., Jan. 20, to Fri., Mar. 5, at the Old Fort, New Delhi, India. Organised by the Ministry of Works, Housing and Supply of the Government of India. Apply to the Director of the exhibition, " P " Block, New Delhi, India.

FOURTH NATIONAL POWER FARMING CONFERENCE. Tues., Wed. and Thurs., Feb. 9, 10 and 11, in the Town Hall, Cheltenham. Organised by the *Power Farmer: Britain and Overseas*, Dorset House, Stamford-street, London, S.E.1. Tel. WATerloo 3333.

FIRE RESEARCH STATION EXHIBITION. Wed., Feb. 10, to Fri., Feb. 26, at the Royal Institute of British Architects, 66 Portland-place, London, W.1. Tel. LANgham 5721. See also this page.

SYMPOSIUM ON OIL FILTRATION IN MODERN INDUSTRY. Thurs. and Fri., Feb. 11 and 12, at the Business Administration and Economics Building, University of California, Los Angeles. Organised by the Department of Engineering of the University, in co-operation with the American Society of Lubrication Engineers. Further information obtainable from the Engineering Extension, University of California, 3076 Engineering Building, Los Angeles 24, California, U.S.A. See also our issue of September 18, 1953, page 360 *ante*.

SCOTTISH HANDICRAFT AND HOMECRAFTS EXHIBITION. Mon., Feb. 22, to Thurs., Mar. 4, at McLellan Galleries, Sauchiehall-street, Glasgow. Organised by Henderson Exhibitions, Ltd., 74 Holland Park, London, W.11. Tel. PARk 7360.

BUSINESS EFFICIENCY EXHIBITION. Tues., Feb. 23, to Fri., Feb. 26, at the Drill Hall, Fenton-street, Leeds. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate-hill, Cannon-street, London, E.C.4. Tel. CENtral 7771.

IDEAL HOME EXHIBITION. Tues., Mar. 2, to Sat., Mar. 27, at Olympia, London, W.14. Organised by Associated Newspapers, Ltd., New Carmelite House, London, E.C.4. Tel. CENtral 6000.

INTERNATIONAL AGRICULTURAL MACHINERY EXHIBITION. Tues., Mar. 2, to Sun., Mar. 7, at Paris. Organised by the Salon International de la Machine Agricole, 95 Rue Saint Lazare, Paris, 9e.

CANADIAN NATIONAL SPORTSMEN'S SHOW. Fri., Mar. 12, to Sat., Mar. 20, at the Coliseum, Toronto. Exhibition of motor-cars, motor-cycles, motor boats and ancillary equipment. British section. Additional information obtainable from the Society of Motor Manufacturers and Traders, 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

34TH VIENNA SPRING TRADE FAIR. Sun., Mar. 14, to Sun., Mar. 21, at Vienna. Apply to the British-Austrian Chamber of Commerce, 29 Dorset-square, London, N.W.1. Tel. PADdington 7646.

THIRD ELECTRICAL ENGINEERS' EXHIBITION. Tues., Mar. 16, to Sat., Mar. 20, at Earl's Court, London, S.W.5. Organised by the Association of Supervising Electrical Engineers, 54 Station-road, New Barnet, Hertfordshire. Apply to Mr. P. A. Thorogood, 35 Gibbs Green, Edgware, Middlesex. Tel. MILl Hill 3528.

CHEMICAL ENGINEERING IN THE FOOD INDUSTRY CONFERENCE. Thurs. and Fri., Mar. 18 and 19, at Wellcome Research Institution, 183-193 Euston-road, London, N.W.1. Organised by the Food Group of the Chemical Engineering Group. Apply to the assistant secretary, Society of Chemical Industry, 56 Victoria-street, London, S.W.1. Tel. VICtoria 5215.

SECOND FACTORY EQUIPMENT EXHIBITION. Mon., Mar. 22, to Fri., Mar. 26, at the two halls of the Royal Horticultural Society, in Vincent-square and Greycoat-street, London, S.W.1. Apply to Mr. J. E. Holdsworth, 117 Kingsway, London, W.C.2. Tel. HOLborn 1414. See also our issue of Aug. 14, 1953, page 218 *ante*.

AMERICAN CHEMICAL SOCIETY, NATIONAL MEETINGS. Wed., Mar. 24, to Thurs., April 1, at Kansas City, Missouri, U.S.A.; and Sunday, September 12, to Friday, September 17, 1954, at New York. Organised by the American Chemical Society, 1155 Sixteenth-street, N.W., Washington 6, D.C., U.S.A.

STOCKHOLM MOTOR SHOW. Fri. Mar. 26, to Sun., April 4, at Stockholm. Organised by St. Eriksmassan A/B., Lidingovagen 10, Stockholm, Sweden.

CONFERENCE ON THE YOUNG WORKER: EDUCATION FOR HUMAN RELATIONS. Sat., April 3, to Fri., April 9, at Manchester College, Oxford. Particulars obtainable from the secretary, Conference on the Young Worker, 15 Norham-gardens, Oxford. Tel. Oxford 58631. See also our issue of November 20, 1953, page 660 *ante*.

SYMPOSIUM ON GAS ABSORPTION. Mon., Tues., and Wed., April 5, 6 and 7, at Birmingham. Organised by the Midlands Branch, Institution of Chemical Engineers. Further information obtainable from the secretary of the Institution, 56 Victoria-street, London, S.W.1. Tel. VICtoria 6161.

CONFERENCE ON THE PHYSICS OF PARTICLE SIZE ANALYSIS. Tues., April 6, to Fri., April 9, at Nottingham University. Organised by the Institute of Physics, 47 Belgrave-square, London, S.W.1. Tel. SLOane 9806.

CONFERENCE ON HARMFUL MATERIALS IN INDUSTRIAL ATMOSPHERES. Tues., April 6, at London School of Hygiene and Tropical Medicine, Keppel-street, London, W.C.1. Organised by the British Occupational Hygiene Society. Apply to Mr. P. C. G. Isaac, Public Health Engineering Laboratory, King's College, Newcastle-upon-Tyne, 1.

11TH RADIO COMPONENTS SHOW. Tues., April 6, to Thurs., April 8, at Grosvenor House, Park-lane, London, W.1. Organised by the Radio and Electronic Manufacturers' Federation, 22 Surrey-street, London, W.C.2. Tel. TEMple Bar 6740.

PHYSICAL SOCIETY'S EXHIBITION. Thurs., April 8, to Tues., April 13, at the Royal College of Science main building, Imperial Institute-road, South Kensington, London, S.W.7. Organised by the Physical Society, 1 Lowther-gardens, London, S.W.7. Tel. KENsington 0048.

LIÉGE INTERNATIONAL FAIR. Sat., April 24, to Sun., May 9, at Liége, Belgium. Apply to the manager, Foire Internationale de Liége, 17 Boulevard d'Avroy, Liége, Belgium. See also our issue of August 14, 1953, page 218 *ante*.

HANOVER LIGHT AND HEAVY INDUSTRIES FAIR. Sun., April 25, to Tues., May 4, at Hanover. *Agents:* Schenkers, Ltd., 27 Chancery-lane, London, W.C.2. Tel. CHAncery 6612.

ROYAL SANITARY INSTITUTE HEALTH CONGRESS. Tues., April 27, to Fri., April 30, at Scarborough. Apply to the secretary of the Institute, 90 Buckingham Palace-road, Westminster, London, S.W.1. Tel. SLOane 5134.

EXHIBITION OF ARCHITECTURE AND BUILDING, AUSTRALIA. Mon., May 3, to Fri., May 28, at Sydney. Held in conjunction with the 1954 Australian Architectural Convention. Organised by the Royal Australian Institute of Architects, 16 Barrack-street, Sydney.

PHOTOGRAPHIC AND CINE EXHIBITION. Tues., May 4, to Sat., May 15, at Manchester. Organised by Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester. Tel. Deansgate 6363.

INTERNATIONAL HIGH TENSION CONFERENCE. Wed., May 12, to Sat., May 22, at 28 Rue Saint Dominique, Paris. Organised by the Conférence Internationale des Grands Réseaux Electriques, 112 Boulevard Haussmann, Paris. Apply to the secretary, C.I.G.R.E. British National Committee, Thorncroft Manor, Dorking-road, Leatherhead, Surrey. Tel. Leatherhead 3423. See also page 62 *ante*.

SIXTH BRITISH ELECTRICAL POWER CONVENTION. Mon., June 14, to Fri., June 18, at Eastbourne. Organised by the British Electrical Development Association, 2 Savoy-hill, London, W.C.2. Tel. TEMple Bar 9434. See also page 71 *ante*.

5TH SYMPOSIUM ON FLAME AND COMBUSTION. Mon., Aug. 30, to Fri., Sept. 3, at the University, Pittsburgh. Apply to the chairman of the organising committee, Dr. B. Lewis, U.S. Bureau of Mines, 4800 Forbes-street, Pittsburgh, U.S.A.

*The Engineering Outlook—4*

# COAL AND ELECTRICITY

## MINING MACHINERY, BOILERS AND HEAVY ELECTRICAL PLANT

IN general, the engineering companies making plant for the fuel and power industries are assured of a continuing high level of output for some time to come, owing largely to the quickening progress of very extensive investment programmes designed to increase the output of coal and electricity in the United Kingdom. The limiting factors since the war have been mainly the shortage of plant and equipment, and of labour for carrying out the contracting work. The demand for fuel and power is growing so rapidly that even the maximum practicable investment will not enable the supply industries to keep pace with requirements unless consumers make more efficient use of their fuel. This will require a substantial outlay by manufacturing industry in modern steam-raising and power plant. Orders for such equipment from industrial users are, however, still disappointingly low. It is to be hoped that special low-interest Exchequer loans, and official encouragement in other ways, will stimulate them in 1954. The flow of orders for many types of steam-raising and heavy electrical plant and mining machinery in the export markets has been somewhat reduced in the past year. This will not in general bring an immediate reduction in exports, although some categories had fallen off in 1953. Order books are still fairly full, and this has brought the advantage that, able to quote prompter delivery, British manufacturers will be able to compete more effectively for the available business.

### INVESTMENT IN COAL

So far, a mild winter has prevented the inadequate supply of coal in the United Kingdom from causing discomfort; and although, largely because of the Coronation and the longer miners' holiday in 1953, output was 1·26 million tons less than in 1952, it was not necessary to put in motion the Government plans, announced in July, for importing large quantities of expensive coal from the United States. Such a temporary reprieve does not lessen the urgency for carrying out the recommendations of the Ridley Committee, who, in their report on "National Policy for the Fuel and Power Resources," pointed out that the output of coal in the United Kingdom is about 15 to 20 million tons below demand at current prices. They estimated, moreover, that by 1959 the annual demand would have risen to between 256 and 267 million tons; whereas in the National Coal Board's *Plan for Coal* it was originally proposed to raise the output only to 240 million tons, or only about 16·5 million tons more than in 1953.

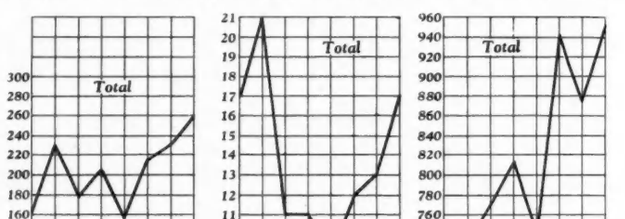
The cost of raising the output above 240 million tons is disproportionately high, but such is the urgency of the situation that the N.C.B. have decided to do everything practicable to meet the Ridley estimates. Progress has been very slow, however; in the five years 1951 to 1955, it was planned that investment in the collieries should average £38 millions, which would mean £53 millions at current prices. The actual expenditure was only £27 millions in 1951, rising to £38 millions in 1952 and £48 millions in 1953. In 1954 it is likely to exceed the planned average for the first time, but, since the official estimate is only £58 millions, little will be done to wipe out the deficit of the previous years. This is all the more serious in view of the statement, in the N.C.B. Report and Accounts for 1952, that the expenditure envisaged in the initial plan may well prove to have been underestimated.

The main reason for failure to carry out the programmes is given as shortage of the trained staff needed to carry out the detailed preparation of reconstruction schemes, the placing of contracts, and the control of their progress. The skilled mining engineer traditionally seeks his career in management rather than in planning, and, because of the pressing need for current output, it has not been possible to release staff from management. Over-centralisation may have contributed to the difficulties, and perhaps has tied up an unduly large number of mining engineers in management; if so, matters are now being rectified. The National Coal Board have now given instuctions that the Area is to be regarded as the proper unit for higher management, and that the colliery manager is to have the maximum responsibility for the day to day management of his pit. Moreover, they are carrying out an examination of their organisation to ensure that it is well adapted to implement the instructions for decentralisation.

### DIFFICULTIES IN OBTAINING EQUIPMENT

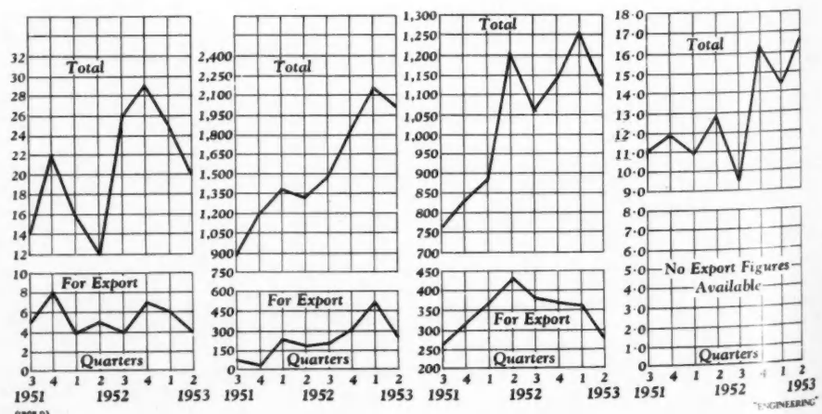
In some instances, progress has been retarded by difficulties in obtaining equipment, but in general the makers of well-established types of mining plant could have increased their deliveries if the N.C.B. had been able to make more headway with the investment programme. As it was, the greater progress achieved in 1953 made it possible to increase greatly the deliveries of many types of coal-mining machinery, as shown in the diagrams below. A notable example of the inability of British manufacturers to meet the N.C.B.'s requirements is in shaft-sinking. To avoid retarding the programmes, it has been necessary to award contracts to German contractors. This action has been severely criticised in many quarters, but it is estimated that the engagement of German contractors, who can supply all the plant required, particularly winding engines, capstans and head-gears, not immediately obtainable in the United Kingdom, will enable a new mine to go into production 18 months sooner than otherwise would have been possible. The value of the contract for Kinneil Colliery at Bo'ness, awarded to the Germans, was £500,000. Imports of this magnitude might seem undesirable, but it is the high cost of sinking shafts and equipping them which has made it difficult for British companies to meet the requirements of the Board's programme.

It has been estimated that a new pair of shafts requires cash and credit for plant facilities amounting to more than a quarter of a million




Coal cutters (number). Power loaders (number). Underground conveyors (number).

**U.K. deliveries of coal-mining machinery. Deliveries increased considerably in 1953, though the National Coal Board were not able to make rapid headway with their investment programme.**




Diesel underground locomotives (number). Coal preparation plant (£1,000). Winding and haulage equipment (£1,000). Tubs and mine cars (1,000 tons).

pounds. The resources of any company engaged on shaft-sinking must, therefore, be very considerable. The present demand from the N.C.B. is exceptional; with the possible exception of the work undertaken in developing the gold mines of the Orange Free State, the shaft-sinking programme is the largest ever undertaken. British contractors would be justified in expanding their capital only if they were assured of a regular high demand. In view of the need to obtain more coal quickly, however, the Board must concentrate most of the shaft-sinking within the space of a relatively few years, so that eventually the demand must tail off considerably.

Conveyors are another item of equipment which British makers have been unable to provide in the quantities required. Substantial orders for armoured flexible types have been placed in Germany. These are an important adjunct in "continuous mining." The N.C.B., in drawing up their *Plan for Coal*, made no allowance for the possibility of raising productivity by new machines and by improved techniques in coal-getting. Nevertheless, good progress is likely to be made in the use of new machines of revolutionary design which can raise output per man-shift very considerably. The use of coal ploughs and the Samson Stripper, which employs a hydraulically-operated wedge to dislodge the coal from the face, is being steadily expanded. The Huwood loader has been combined with a specially equipped coal-cutter to make a cutter-loader suitable for work in thin seams. The number of Meco-Moore machines, the earliest form of cutter-loader in use, has increased substantially. In 1952, 112 such machines produced over 6·25 million tons of coal. The total quantity of coal power-loaded in that year was 11·1 million tons, compared with 8·7 millions in 1951. It has been found possible to adapt the Meco-Moore machine to work two shifts in 24 hours, thus doubling its productivity. Formerly, the difficulty of turning them round at the end of the run along the coal face prevented their use in more than one shift in the 24 hours.

## PROPOSALS FOR INCREASING OUTPUT

The rate of development of new machines, however, has not been as fast as the N.C.B. would like. The chairman of the Board, Sir Hubert Houldsworth, said in an address to the Institution of Mining Engineers in July that the Board's scheme for giving grants to people who put forward practical proposals for increasing output had produced a flood of useful suggestions, but that there was great difficulty in translating these into prototype machines, and even greater difficulties in getting the prototypes into production quickly enough. There were many machines in course of development which were worthy of more extensive trials than they had as yet received, but the Board could not get them fast enough.

## CONSERVING COAL

The N.C.B. have taken very seriously their duty to give a lead in fuel efficiency. The colliery consumption of coal per unit of output has fallen steadily since 1947. Headquarters maintain mobile fuel-efficiency teams. Areas are building up their own fuel-efficiency services, and boiler-house plant is steadily being made more efficient. Progress is also being made with the utilisation of coal slurry, of which about 5 million tons are at present going to waste. The N.C.B. have set up a pilot plant for pelleting the slurry, which can then be used in pit-head furnace plant. Increasing use is also being made of "fines," which will be produced in increasing quantity as mechanisation proceeds. A plant for turning a million tons of "fines" into briquettes is already in operation. The British Coal Utilisation Research Association have done much valuable work in this direction, as well as in improving the efficiency of fuel consumption in domestic fires and in shell boilers. Sir Ben Lockspeiser, addressing the Association in October, said that neither science nor technology was lacking in the United Kingdom for saving 15 to 20 million tons of coal a year.

Government action is following three main courses. Loans are being made available to industry at nominal interest rates for the purchase of plant which will raise fuel efficiency; a non-profit making company has been formed, sponsored by the British Productivity Council, to take up the work of fuel efficiency; and, finally, a survey is being made of the use of steam by industry. This may be expected to yield systematic knowledge of the potentialities of power generation by back-pressure methods. Already it has emerged that one-fifth of the industrial boilers in use are over 40 years old and that the substitution of modern equipment would yield a saving of 2 million tons of coal a year.

The realisation of all potential savings of this kind, coupled with the maximum practical investment by the N.C.B., should just about bridge the gap between production and consumption in 1960, but the amount of power available in the United Kingdom will still be very small compared with the United States. In order to reach American standards, the British consumption of coal should be more than twice as great as at present, or about 500 million tons per annum, rising to 1,000 million tons in 1975. It might be possible, perhaps, to achieve high productivity with rather lower power consumption than in the United States; but, nevertheless, it is fairly clear that the United Kingdom will survive as an industrial nation only if the power behind each workman is brought more in line with that in the United States.

The demand for mining machinery abroad has been falling. The volume of British exports, as may be seen from Tables I and II, taken from the *Trade and Navigation Accounts*, was more than a quarter less than in 1951 and 12 per cent. lower than in 1952. Fortunately, partly owing to exports of more expensive types of machinery, the value of British exports has declined comparatively little. Exports of cutter-loaders have actually increased. The fall in exports has been due more to the slackening in demand from the metalliferous than from the coal-mining industries, as may be confirmed from the figures for South Africa and Malaya. The demand for coal-mining machinery has increased in some instances, notably in Poland. Exports to Australia increased substantially in 1953, but are likely to fall fairly sharply in 1954. The Australian Joint Coal Board have decided to sell surplus open-cast mining equipment to the value of nearly £4 millions, purchased during a period of acute coal shortage in 1949. At that time it was estimated that the demand for coal from New South Wales would rise to 80 million tons by 1953, but it has not exceeded 14 million tons.

## ELECTRICITY SUPPLIES AND PLANT

One of the most important factors limiting investment in electricity is the shortage of coal. The present programme of the British Electricity Authority for increasing capacity will put a heavy strain on the available supplies, since it will mean increasing the B.E.A. consumption by 13 million tons, bringing it to a total of 50·2 million tons by 1959. Moreover, Lord Citrine has given his opinion that the present programmes may well prove to be inadequate. They involve adding 1·45 million kW sent-out capacity in 1954, rising progressively to 1·75 million kW in 1957; but the demand for electricity is increasing even more rapidly, and the annual need for new capacity by 1960 may be not less than 2·1 million kW. It is quite possible, too, that the extent of the increase in demand has been underestimated, and that the power-supply position may be considerably worse in five years than it is to-day.

Some slight relief from the pressure of demand on coal will be obtained by the use of atomic energy from the new nuclear establishment at Calder Hall in Cumberland, and in the near future nuclear energy should contribute 50,000 kW to power resources. It is still, however, too early to say what the eventual contribution from atomic power stations is likely to be, or when they will begin to make any significant increase in the supply of electricity. The use of water power will be extended as far as possible. In North Wales, the hydro-electric schemes at Dolgarrog and Maentwrog will extend capacity by 10,000 kW. The North of Scotland Hydro-Electric Board have already placed the first contract for the Breadalbane scheme, which will yield an annual output of 304 million units of electricity. Although, while the need to limit capital investment persists, the construction of the Severn Barrage is impracticable, the Department of Scientific and Industrial Research

TABLE I. United Kingdom: Exports of Mining Machinery other than Portable Power Tools. (January to November.)

| — | Quantity (1,000 cwt.) | | | Value (£1,000) | | |
|---|---|---|---|---|---|---|
| | 1951 | 1952 | 1953 | 1951 | 1952 | 1953 |
| Power-operated coal cutters | 28 | 19 | 23 | 702 | 550 | 725 |
| Power-operated winders | 55 | 76 | 64 | 610 | 1,026 | 865 |
| Underground conveyors | 97 | 100 | 93 | 722 | 842 | 896 |
| Others | 206 | 153 | 102 | 2,524 | 2,168 | 1,853 |
| | 386 | 348 | 282 | 4,558 | 4,586 | 4,339 |

TABLE II. United Kingdom: Exports of Mining Machinery other than Portable Tools, by Countries of Destination. (January to November.)

| — | Quantity (1,000 cwt.) | | | Value (£1,000) | | |
|---|---|---|---|---|---|---|
| | 1951 | 1952 | 1953 | 1951 | 1952 | 1953 |
| British West Africa | 17 | 11 | 15 | 192 | 182 | 215 |
| Union of South Africa | 72 | 85 | 57 | 952 | 1,173 | 907 |
| India | 24 | 26 | 17 | 353 | 385 | 287 |
| Malaya | 60 | 41 | 8 | 441 | 338 | 75 |
| Australia | 46 | 55 | 59 | 516 | 546 | 652 |
| Other Commonwealth countries and the Irish Republic | 48 | 52 | 54 | 581 | 624 | 778 |
| Poland | 16 | 2 | 3 | 340 | 55 | 80 |
| France | 5 | 8 | 8 | 111 | 165 | 222 |
| Other foreign countries | 98 | 68 | 61 | 1,072 | 1,119 | 1,123 |
| | 386 | 348 | 282 | 4,558 | 4,586 | 4,339 |

is constructing a tidal model so that investigation of the project can proceed.

## PEAT POWER STATIONS

Savings from the use of peat may eventually be considerable. There are estimated to be 600 million tons of peat solids available for utilisation in Scotland, of which 130 millions are in Caithness and Sutherland. The construction of a power station at Altnabreac to tap these supplies has already been put in hand; the capital and development costs are estimated at £500,000. The plant will consist partly of a 2,000-kW closed-cycle turbine of the type developed by John Brown and Company, Clydebank. A gas turbine burning dried peat has been run successfully for 1,000 hours at Clydebank and the new peat plant will be a development of this. It will also include a 750-kW open-cycle turbine, made by Ruston and Hornsby, Limited. The whole pilot scheme will take three to four years to carry out. If it is successful, larger projects will be put in hand in other areas.

The use of gas turbines with more orthodox fuels will also undoubtedly have a contribution to make towards conserving the national resources. The B.E.A. have already installed two such turbines of 15,000 kW each; these are only experimental, but should provide valuable information for later developments. The possibility of using wind power is also being explored but these experiments are still at an early stage, and are confined mainly to work with a 100-kW generator. At one time it was thought that there might be considerable scope for the employment of Diesel-engined generators, and the B.E.A. considered a proposal for installing plant with a capacity of 100 kW. It was not found possible, however, to install the plant as quickly or as cheaply as had been hoped, and it was decided that only 50,000 kW should be ordered for installation before the end of 1954.

## ECONOMIES IN ELECTRICITY GENERATION

Despite all the new developments, conventional thermal generating stations burning coal will have to be relied on to provide most of the capacity required for 1960. Most of the plant in the current programmes consists of standard 30,000-kW and 60,000-kW turbo-generator sets, although, in addition to six of the smaller standard sets and nine of the larger, the programme for 1958 includes one 120,000-kW set. Coal consumption is to be kept to a minimum by strict attention to fuel economy. The B.E.A. claim that much has been done already in this direction. Improvements in thermal efficiency in the five years since vesting day have resulted in the saving of about 7·25 million tons of coal, and stations with an efficiency of 22 per cent. and over are now producing three-quarters of the total output of electricity, compared with about two-thirds in 1951,

Nevertheless, much work still remains to be done; about 13 per cent. of the total evaporative capacity comprises boilers over 25 years old, and 6·3 per cent. comprises boilers with individual capacities less than 40,000 lb. per hour. New boiler-plants are being planned to consume the low grades of coal for which there is least demand from other consumers, the main requirement of the B.E.A. being that quality should be consistent. As a result of a review of coal supplies, made in collaboration with the N.C.B., it seems that the major part of the B.E.A.'s additional requirements will have to come from the East Midlands, with lesser quantities from Yorkshire, the West Midlands and East Scotland. Obviously, this has an important bearing on the siting of power stations and on distribution systems.

The cost of electrical transmission per unit of energy is less than that of transporting coal except where it is possible to use sea transport with short rail hauls at the pit end, and to deliver directly to dock-side power stations. The desirability of building large stations near estuaries by the sea coast, where there is the added advantage of readily available water for cooling towers, has been stressed in the report, published in April, of a productivity team from the United States who inspected the British electrical supply industry; but, apart from any technical considerations, this could be ruled out on strategic grounds. It has been decided, therefore, that the greatest economies in generating and transmitting electricity are to be obtained by centralising production in large power stations situated near the coal-fields. This will be in part the function of the new 275-kV "super-grid," of which the first 40 miles are already in use. It will take seven years to complete, and, at first sight, the projected outlay of £52 millions may seem excessive, particularly when the American team considered that it might have been feasible to make greater use of the existing 133-kV grid and to extend it, at less cost. The B.E.A. have pointed out that provision for bulk transmission of current to reduce the transport costs of coal is not the only justification for the super-grid; by providing interconnection facilities for the pooling of generating plant, it has made possible savings in new capacity out of all relation to its own cost. The 133-kV system was not designed, in the first instance, for the transfer of power from one area to another, and in any case, it is overloaded.

## COST OF POWER STATIONS

Some criticisms of unduly high costs in the expansion of British generating capacity, however, seem to have been well-founded. A committee, under the chairmanship of Sir Hugh Beaver, appointed by the Ministry of Fuel and Power to consider the possibilities for economies in power-station construction, reported in October that past expenditure on civil engineering and building work had been extravagant. It was conceded that the B.E.A. had done much towards achieving more scrupulous standards of economy in power-station design and equipment, but much more could be done. Greater standardisation in station design, for instance, might cut costs by 10 to 15 per cent.; much ancillary equipment could with advantage be standardised; and it should be possible to make further reductions in the amount of covered space per unit of installed capacity. Already the amount of space per kilowatt for stations with 100,000-kW sets has been reduced from 60 to 26 cub. ft. Since present programmes are costing about £150 millions per annum, quite small percentage economies all round could lessen appreciably this strain on the national resources.

One method of reducing the burden has been rejected by the B.E.A. This is the simple one of reducing the demand for electricity by increasing tariffs, which was at least partly endorsed by the Ridley Committee when they recommended that the B.E.A. should discriminate in charges made for electricity at times of peak and off-peak load. There are, however, great practical difficulties in such a course, and to raise tariffs indiscriminately must inevitably add to manufacturing costs and to the difficulties of exporters. Moreover, it is not necessarily desirable to reduce the demand from domestic consumers by higher different tariffs, for, by balancing the load, they help to keep down charges for industrial consumers. Reduced consumption of electricity would simply push up generating costs. If the need to provide British industry with as much power, as cheaply as possible, is accepted as of over-riding importance in the interests of increasing productivity, it follows that the B.E.A. must do everything in their power to increase generating capacity within the limits of the available fuel supplies. In the interests of a balanced load this will also involve raising low-priority domestic consumption; but it does not mean that wasteful investment is being undertaken.

## EXPORTS OF HEAVY ELECTRICAL PLANT

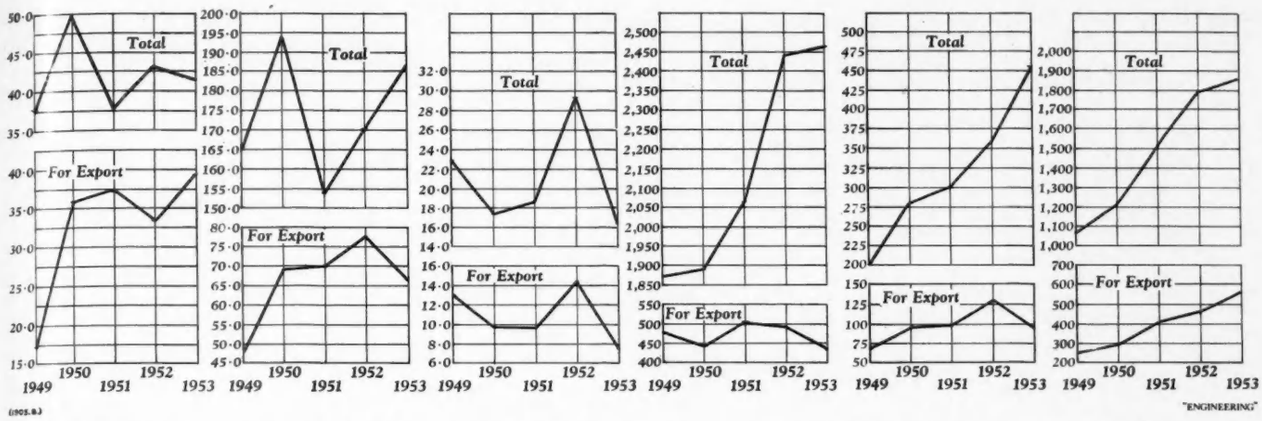
The amount of new generating capacity installed by the B.E.A. in 1953 was again at a high level, the net increase amounting to 1,413 MW. As shown in the diagrams above, the output of heavy electrical plant again increased, although that of small steam turbines and hydraulic turbines fell. As may be seen from Table III, taken from the *Trade and Navigation*

TABLE III. UNITED KINGDOM: EXPORTS OF ELECTRICAL MACHINERY. (JANUARY TO NOVEMBER.)

| — | Quantity (1,000 cwt.) | | | Value (£1,000) | | |
|---|---|---|---|---|---|---|
| | 1951 | 1952 | 1953 | 1951 | 1952 | 1953 |
| Generators complete : | | | | | | |
| Driven by Diesel engines : | | | | | | |
| Not exceeding 200 kW .. | 184 | 169 | 131 | 4,267 | 4,536 | 3,530 |
| Exceeding 200 kW .. .. | 83 | 106 | 71 | 1,668 | 2,335 | 1,749 |
| Other generators .. .. | 92 | 66 | 77 | 2,425 | 1,914 | 2,519 |
| Generators without prime movers and parts .. .. .. | 184 | 222 | 272 | 4,809 | 6,193 | 7,739 |
| | 543 | 563 | 551 | 13,169 | 14,978 | 15,537 |
| Converting machinery .. .. | 11 | 14 | 13 | 209 | 453 | 419 |
| Transformers .. .. .. | 508 | 557 | 606 | 7,961 | 9,575 | 11,154 |
| Rectifiers for powerhouse use .. | 21 | 20 | 16 | 623 | 718 | 631 |
| Starting and controlling gear .. | 63 | 71 | 65 | 1,939 | 2,545 | 2,564 |
| Switchgear and switchboards .. | 387 | 429 | 417 | 11,506 | 14,159 | 14,718 |
| Steam turbines .. .. .. | 115 | 105 | 133 | 3,518 | 3,570 | 5,030 |
| | 1,105 | 1,196 | 1,250 | 25,756 | 31,020 | 34,516 |

TABLE IV. UNITED KINGDOM: EXPORTS OF BOILERS AND BOILER-HOUSE PLANT. (JANUARY TO NOVEMBER.)

| — | Quantity (1,000 cwt.) | | | Value (£1,000) | | |
|---|---|---|---|---|---|---|
| | 1951 | 1952 | 1953 | 1951 | 1952 | 1953 |
| Water-tube boilers .. .. | 744 | 709 | 573 | 6,127 | 6,388 | 6,450 |
| Lancashire and Cornish boilers .. | 25 | 16 | 8 | 169 | 104 | 59 |
| Vertical boilers .. .. .. | 46 | 38 | 29 | 389 | 369 | 357 |
| Other boilers .. .. .. | 128 | 147 | 160 | 1,133 | 1,303 | 1,385 |
| Economisers, feed-water heaters, and steam superheaters .. | 116 | 135 | 124 | 958 | 1,243 | 1,086 |
| Other boiler-house plant .. | 282 | 381 | 400 | 3,182 | 4,577 | 5,393 |
| | 1,341 | 1,426 | 1,294 | 11,958 | 13,984 | 14,730 |




Hydraulic turbines (1,000 B.H.P.). | Steam turbo-alternators 10 MW and over (1-MW units). | Steam turbines less than 10 MW (1-MW units). | Rotating electrical machines 1-250 H.P., kVA or kW (£1,000 units). | Rotating electrical machines Over 250 H.P., kVA or kW (£1,000 units). | Electrical control gear (£1,000 units).

**U.K. deliveries of electrical plant and machinery (monthly averages, with 1953 figures based on 9-month totals). The diagrams show that output increased in 1953, except for small steam turbines and hydraulic turbines.**

*Accounts*, exports of large generators and generating sets also increased, though exports of lighter equipment fell off considerably. The B.E.A., in their annual *Report and Accounts* for the year ending March, 1953, complained that the priority which the Treasury had accorded to exports was interfering with their programmes, and representations were made to ensure that, while maximum attention is given to exports, the B.E.A. programme shall not be subject to costly delays. Weakening demand in the export markets may help to solve the problem, but order books are still full, and, even if it were in the national interests, there will be no immediate relief. The export prospect, however, is by no means bleak; there have been encouraging developments in dollar markets.

When the United States Government announced that, because of the deficient information provided to manufacturers in the first instance, they proposed to ask for new tenders for equipment for their Chief Joseph power project, this was thought to be a move, despite all declarations to the contrary, to enforce a more rigid "Buy American Policy." To many observers it appeared that the Americans were seeking to reject, on a technicality, a tender by the English Electric Company which had been considerably below that of native American manufacturers. When new tenders were submitted the latter naturally took the opportunity of cutting their quotations, and, in fact, the Westinghouse Electric Company, of the United States, had their tender for generators accepted, since it was nearly 100,000 dols. less than that submitted by the English Electric Company. The English Electric Company, however, were awarded a contract in June for ten transformers to the value of 1·76 million dols. Since then, there has been further evidence of American good faith in the pursuit of a more liberal trade policy. It was announced in December that the English Electric Company, by under-bidding four competing American companies, had won a contract valued at 3·65 million dols. for supplying two generators for the McNary Dam project.

## COMMONWEALTH MARKETS

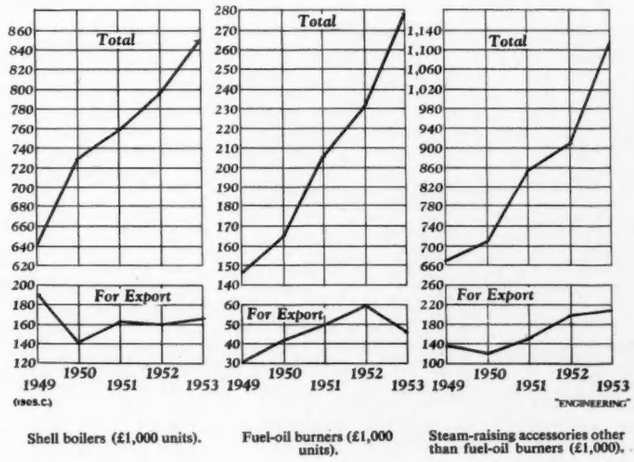
The Commonwealth continues to be the best market for British generating plant. C. A. Parsons and Company, Limited, completed a 100,000-kW turbo-generator set for the Richard L. Hearn generating station in Canada in 1953, and have received orders for three 60,000-kW sets for the Lake Macquarie power station in Australia, and a third 30,000-kW set for the power house at Bulawayo, Southern Rhodesia. The English Electric Company commissioned the third and fourth 66,000-kW sets for the Hydro-Electric Power Commission of Ontario, and three of ten 30,000-kW sets for Vierfontein, South Africa; another is ready for steam. The British Thomson-Houston Company, besides handing over 225,000 kW to the B.E.A., installed a 25,000-kW turbo-alternator set for the Ford Motor Company in Canada, another in the Colenso power station in South Africa, and smaller sets in Trinidad, Australia, East Africa and other markets.

India is, perhaps, the least promising of all Commonwealth markets. The Government have invited the (German) Siemens company to prepare a project report for the manufacture of heavy electrical equipment in India, and a team of eight experts arrived in August. Reports have already been submitted by Associated Electrical Industries (India), Limited, the Westinghouse Electrical International Company, and the International General Electric Company. These reports, submitted towards the end of 1949, provided for the production of heavy power plant with an aggregate capacity of 300,000 kW per year. There was, however, a considerable difficulty at the time in finding the necessary finance, and only the Westinghouse Company were willing to participate financially. It has now been decided that Rs. 70 millions should be allotted to the project out of the total provision of Rs. 500 millions for the Five Year Plan for basic industries and transport. No doubt, it will be a considerable point in the Germans' favour if they should be willing to provide some part of the capital.

## BOILERS

As may be seen from Table IV, taken from the *Trade and Navigation Accounts*, exports of boilers and boiler-house plant were somewhat higher in value in 1953 than in 1952; the increase in volume was rather smaller, however, and the exports of some types actually declined considerably. A fall of nearly one-fifth in the volume of exports of water-tube boilers is particularly striking, but may be due, to a large extent, simply to the irregularity of delivery inevitable in equipment of this kind. Order books have been somewhat reduced, but, as yet, this cannot have resulted in a reduced flow of exports. Capacity for the production of water-tube boilers has increased materially in the past two years, and the output in 1953 was a record. Official figures show that the number of new boilers put into service for the B.E.A. was 68, compared with 59 in 1952.

The output of shell boilers and steam-raising accessories, as illustrated by the diagrams below, also increased in 1953; but only value figures are available, and much of the rise of 10 per cent., indicated for shell boilers, may be due to higher prices. Order books have considerably shortened. In some cases, output may be affected in 1954 if Government measures for increasing fuel efficiency are unsuccessful. But as makers are now able to give reasonable delivery, the flow of export orders should increase.




Shell boilers (£1,000 units). | Fuel-oil burners (£1,000 units). | Steam-raising accessories other than fuel-oil burners (£1,000).

**U.K. deliveries of steam-raising plant (monthly averages, 1953 figures based on 10-month totals). The diagrams show increases in 1953, but as only value figures are available much of the rise of 10 per cent. for shell boilers may be due to higher prices.**

*Book Reviews*

# BOILER HOUSE PRACTICE

**Boiler House Practice.** By J. N. WILLIAMS, M.I.Mech.E., M.Inst.F. *George Allen and Unwin, Limited, Ruskin House, 40, Museum-street, London, W.C.*1. (60*s.*)

This survey of modern boiler-house engineering is of so comprehensive a nature that it is difficult to convey an adequate idea of its contents in a short review. It is mainly concerned with the equipment and operating practice of large central station installations, though smaller industrial plants with shell-type boilers, hand fired and otherwise, receive a fair amount of attention. Mechanical stoking, pulverised coal and oil firing, automatic control systems, draught fans, superheaters, economisers, air heaters, feed-pumps, evaporators, water and steam meters and other instruments all come under more or less detailed consideration.

The selection of material for description appears to be as representative and unbiased as could be desired, with no prominence given to the names of the manufacturers concerned. The motive throughout has been to call attention to the principles underlying the designs and to indicate their suitability or otherwise for particular duties. Operational methods, including the firing and management of shell boilers, the internal descaling of boilers by acid treatment, the removal of external deposits by steam soaking or otherwise, the purification of steam to avoid corrosion of superheaters or the fouling of turbine blades, the various ways of treating water, and innumerable other matters are also dealt with in a really useful manner. Neither is the consideration of material and practice confined to the four walls of the boiler-house, for such subjects as the nature and properties of coal and coke, dry and wet processes of coal cleaning, the handling and storage of coal, the emission from chimneys and the cleaning of flue gas are also brought under review.

The book is one that can be read with interest from cover to cover by all men with experience of boiler plant, who will appreciate the mastery of his subject displayed by the author. It can also be unreservedly recommended to engineering students on account of the vast amount of practical information it gives on so many subjects. Matters that might be thought obvious by most of their elders are not overlooked ; for example, the fact that the admission of excess air to a boiler furnace will raise instead of lower the temperature of the flue gases ; the inefficiency of keeping any boilers of a battery idle, as standby, while the rest are steaming at their full rating ; and the dreadful wastefulness of using steam jets as a means of improving the draught.

Except for chapters on combustion and heat transmission at the beginning of the book, there is almost nothing that could be classed as " theory." In the first of these chapters, the author gives a formula, first published in ENGINEERING, vol. 157, page 375 (1944), for determining the maximum theoretical percentage of $CO_2$ in the flue gases from any fuel by means of a simple Orsat test taken when no CO is present, and he points out the usefulness of this figure in determining the amount of excess air at any time. He might well have added that, by writing the formula as

$$M = \frac{21\,(CO_2 + CO)}{21 - O_2 + 0{\cdot}395\,CO}$$

it is equally serviceable whether there is any CO present or not ; also that a knowledge of the value of M enables the theoretical weight of moisture in the gases per lb. of combustible to be ascertained, thus providing a valuable check on the improper presence of steam in the flues. Later, in connection with steam, he describes the well-known methods of measuring the dryness fraction by throttling calorimeters and baffle separators, but ignores entirely the much simpler, cheaper and more accurate method of condensing a sample of the steam in a Thermos flask partly filled with cold water, and computing its dryness fraction from the increase of the weight and temperature of the water. These, however, are inconsiderable defects in an exceptionally good book.

**The M.K.S. System of Units. A Guide for Electrical Engineers.** By T. MCGREEVY. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.*2. (21*s.*)

In electrical and magnetic measurements since 1881 three main systems of units have been employed – the C.G.S. electrostatic system, the C.G.S. electromagnetic system and the practical system based on multiples and submultiples of the C.G.S. electromagnetic system. Other variations such as the Gaussian system borrowing certain units from the above systems are often used, while various proposals for " rationalisation " have been advocated by Heaviside and Lorentz, among others. These systems being interrelated and not independent, conversion from one to another has always imposed a tax on the memory and constituted a frequent source of error. As long ago as 1901 Professor Giorgi pointed out that an absolute electromagnetic system of units could be devised preserving the practical units as absolute units by substituting the metre and kilogramme for the centimetre and gramme as units of length and mass respectively. It was not, however, until 1935 that the adoption of his system was recommended by the International Electrotechnical Commission and its final official decision regarding rationalisation was only taken in 1950. The Giorgi or M.K.S. system has the great advantage of being a single coherent system so that no conversion factors are required to change from a magnetic or electromagnetic quantity to the same quantity in an equation in electrostatics.

Mr. McGreevy has adopted two separate lines of approach in this book corresponding to the needs of two main classes of reader : the engineer and physicist brought up on the C.G.S. system but who will in future encounter with increasing frequency measurements expressed in M.K.S. units, and the student starting his training who should be introduced to the M.K.S. system at the outset. The former class is catered for in the first five chapters where the new system is approached from the old one, and due attention is devoted to the conversion of formulæ from the C.G.S. to the M.K.S. system. The requirements of the latter are thoroughly dealt with in Chapters VI to XVI, wherein are outlined methods that the author has found suitable in presenting the rationalised M.K.S. system to full and part-time students of electrical engineering. A strong case is made for considering electromagnetism as basic and permanent magnetism as an auxiliary experimental subject, for teaching magnetostatics without recourse to that artificial entity the magnetic pole, for regarding magnetic phenomena as manifestations of moving electric charges and for eliminating the doubtful notion of a demagnetising action due to surface polarity. Matters liable to cause confusion, such as the distinction between B and H or between electric intensity and displacement, are carefully explained. The numerous examples, covering representative technical problems and various aspects of circuit and field theory worked out in full, are well designed to develop confidence in the handling of M.K.S. units. There is a sane discussion on dimensions while the final " Summary and General Conclusions " exhibits fully and fairly the many advantages and the few drawbacks of the M.K.S. system. This comprehensive treatment of a subject of topical interest and fundamental importance will be indispensable to teachers and students of electrical engineering and physics.

## TRADE PUBLICATIONS

**Radius Forming on Grinding Wheels.** We have received from Engineering Diamonds, Ltd., 26, Warwick-row, Coventry, makers of the range of " Endia " diamond tools for grinding-wheel dressing, a leaflet describing a new device for accurately forming the radii of wheels used for the internal grinding of such pieces as ball-race tracks, ball-joint seatings and similarly radiused forms.

**Control Details for Radio Sets.** The Plessey Co., Ltd., Ilford, Essex, have issued a booklet, for manufacturers only, which describes their range of ball-drives and couplings for radio set controls. Electric tuning motors, which are also suitable for driving certain types of servo mechanisms, are included.

**" Pay-As-You-See " Television.** International Telemeter Corporation, 2000, Stoner-avenue, Los Angeles 25, California, have sent us a pamphlet describing the meters which form part of the television system at Palm Springs. These allow programmes to be viewed after pre-payment in cash. A special service of lectures for students is provided and subsequently questions shown on the screen can be answered in the affirmative or negative by pressing a button.

**Coronation Telecommunications.** Standard Telephones and Cables, Ltd., Aldwych, London, W.C.2, have sent us a handsome booklet describing and illustrated the contribution made by them to the telecommunication arrangements for the Coronation. Details of the sound reproduction system installed in Westminster Abbey are given, as well as of the super high-frequency links, which enabled television programmes to be relayed to the Continent. Another contribution was a mobile automatic radio direction-finding installation which was used as an aid during the aircraft fly-past. This was all in addition to a great deal of permanent equipment of various kinds.

★ ★ ★

## BOOKS RECEIVED

**The Exporter's Year Book 1954.** Edited by ARTHUR J. DAY. *The " Syren and Shipping," Limited, 26-28, Billiter-street, London, E.C.*3. [40*s.* post free.]

**Symposium on Tin.** Presented at the Fifty-fifth Annual Meeting, New York, June 23, 1952. *American Society for Testing Materials*, 1916, *Race-street, Philadelphia* 3, *Pennsylvania, U.S.A.* [2·50 dols.]

**Coal Mines Act 1911. Regulations and Orders Relating to Safety and Health.** 1953 edition. *H.M. Stationery Office, Kingsway, London, W.C.*2. [4*s.* net.]

**Employee Remuneration and Incentives.** *The Institute of Cost and Works Accountants*, 63, *Portland-place, London, W.*1. [7*s.* 6*d.*]

**Gears.** By DR. H. E. MERRITT. Third edition. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.*2. [60*s.* net.]

**Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for the Year 1952.** *H.M. Stationery Office, Kingsway, London, W.C.*2. [2*s.* 6*d.* net.]

**Some Aspects of the Motor Vehicle Industry in the U.S.A.** *Organisation for European Economic Co-operation*, 2, *Rue André-Pascal, Paris* [16*e*]; *and H.M. Stationery Office, Kingsway, London, W.C.*2 [6*s.*]

**A Manual of Time and Motion Study.** By JOHN W. HENDRY. Fourth edition. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.*2. [15*s.* net.]

**The Directory of Shipowners, Shipbuilders and Marine Engineers 1954.** *Tothill Press Limited*, 33, *Tothill-street, London, S.W.*1. [40*s.* net.]

**The Synchronous Induction Motor.** By J. GRIFFIN. *Macdonald and Company (Publishers) Limited*, 16, *Maddox-street, London, W.*1. [18*s.* net.]

**Handbook of the Fan Engineering Industry.** *Fan Manufacturers' Association Limited*, 59-62, *High Holborn, London, W.C.*1. [3*s.* 6*d.* post free.]

**Theory of Machines.** By BEVIS BRUNEL LOW. *Longmans, Green and Company, Limited*, 6 *and* 7, *Clifford-street, London, W.*1. [25*s.* net.]

**Chromium.** By DR. A. H. SULLY. [35*s.*] **Zirconium.** By DR. G. L. MILLER. [45*s.*]. Metallurgy of the Rarer Metals Nos. 1 and 2. *Butterworths Scientific Publications*, 88, *Kingsway, London, W.C.*2.

**The British Chamber of Commerce, France.** Year Book 1954. *Offices of the Chamber*, 6, *Rue Halévy, Paris.* [9*e.*]

# DEVIATIONS FROM HOOKE'S LAW WITHIN THE "ELASTIC RANGE"

*By Duncan Morrison*, B.Sc.

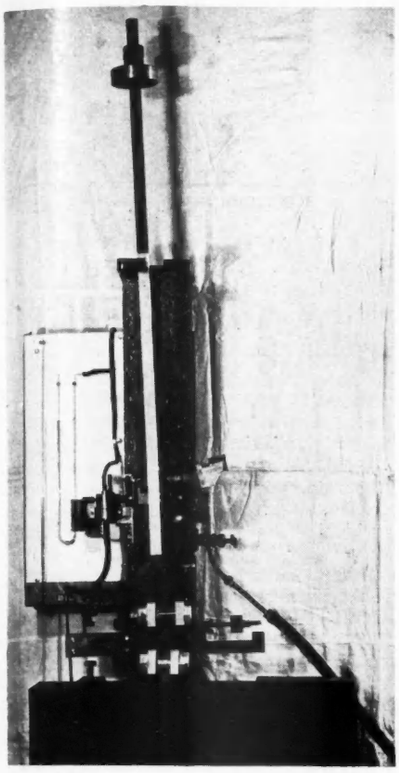


Fig. 1 General view of apparatus.

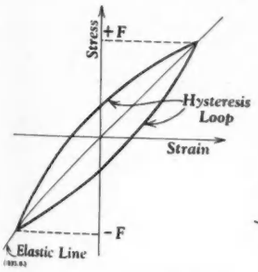



Fig. 2 Stress-strain diagram, showing hysteresis loop.

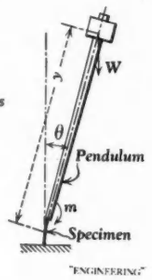



Fig. 3 Principle of operation of apparatus.

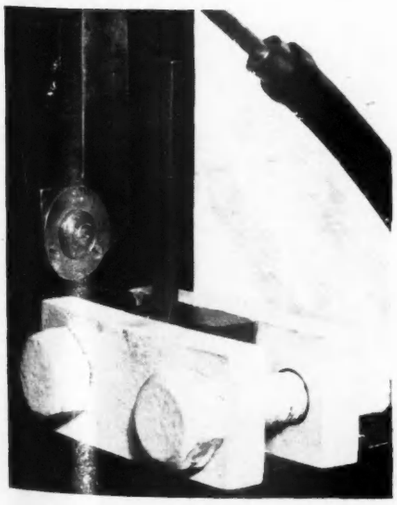


Fig. 4 Specimen mounted in clamp.

In brief, the present article describes an apparatus developed for the measurement of the very small plastic strains occurring in steel at stresses within the so-called "elastic limit," such measurements being of particular interest in the study of damping capacity, or elastic hysteresis. An important feature of the apparatus is that it determines the absolute shape of the hysteresis loop shown in Fig. 2. The accuracy is such that departures from Hooke's Law of as little as 1 lb. per square inch are detectable. A few results obtained from mild-steel specimens are given.

Previous researches by Bairstow, Rowett, Dorey and Föppl* on damping capacity in steels at moderate stresses indicate that the effect is probably due to small plastic strains occurring at stresses within the "elastic limit." Plastic strain of this nature would give rise to a hysteresis loop in the stress-strain diagram seen in Fig. 2, with a consequent loss of energy at each stress cycle. The apparatus described in this article has been developed for the measurement of hysteresis loops of this nature. An advantage over apparatus used by previous investigators is that the absolute shape of the hysteresis loop is obtained and not merely its area or strain width. The specimen is subjected to a static bending test and a mathematical method has been developed for the conversion of the resulting moment-angular deflection curves, to the corresponding stress-strain curves.

A general view of the apparatus is given in Fig. 1, and the basic principle of operation is described with reference to Fig. 3. The specimen is fixed at its lower end to a rigid base and carries at its upper end a heavy inverted pendulum, both connections being made by rigid clamps. The pendulum and specimens are deflected to an angle $\theta$ from the original vertical position by the application of an external moment $m$. If the total moment-angular deflection diagram of the specimen is considered as being made up of a truly linear part (i.e., a moment directly proportional to the angular deflection) plus a non-linear part accounting for such a phenomenon as hysteresis, then the linear part can be offset by the over-toppling moment of the pendulum, leaving moment $m$ corresponding, for the greater part, to the non-linear function being investigated. Putting this in algebraic form

$$\left.\begin{matrix}\text{Internal resisting}\\ \text{moment of}\\ \text{specimen.}\end{matrix}\right\} = \left\{\begin{matrix}\text{Total clockwise}\\ \text{moment of}\\ \text{pendulum.}\end{matrix}\right.$$

$$\text{i.e.,}\quad k\,\theta + \mathrm{F}(\theta) = \mathrm{W}\,y\sin\theta + m$$

$$\text{or}\qquad m = (k - \mathrm{W}\,y)\,\theta + \mathrm{F}(\theta)$$

where $k$ is the elastic stiffness of the specimen in lb. in. per radian ; W the weight of pendulum effectively concentrated at a distance $y$ from the mid-point of the specimen, and F ($\theta$) is a non-linear function of angular deflection making up the hysteresis loop.

The desired experimental condition is attained by making W $y$ approximately equal to $k$, in which case, moment $m$ consists mainly of the function F ($\theta$). The assumption $\sin\theta = \theta$ is justified for small values of $\theta$ and the error involved is, in any case, easily calculable. For the determination of a hysteresis loop, angle $\theta$ is varied in steps to give an alternating deflection, say $\pm\,\Phi$. The corresponding moment $m$ is measured at each step and then plotting $m$ on a base of $\theta$ the required hysteresis loop is obtained.

## PRACTICAL DIMENSIONS OF APPARATUS

A 1-in. square steel bar about 4 ft. long is used for the pendulum and this, together with an adjustable bob-weight, gives a value of about 500 lb.-in. for the product W $y$, thus defining a stiffness ($k$) of about 500 lb. in. per radian for the specimen. Apart from this preliminary requirement of overall stiffness several other factors enter into the design of the specimen. These are briefly,

(*a*) that the working length should be small compared with the length of the pendulum in order to obtain a substantially uniform bending moment,

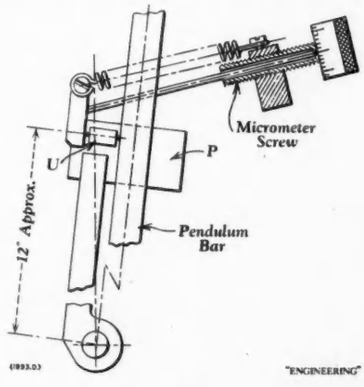
(*b*) that, in a steel specimen, a reasonably high bending stress (say, 20 tons per square inch) will be obtained with a small angular deflection of the pendulum (not more than, say, 0·05 radian),

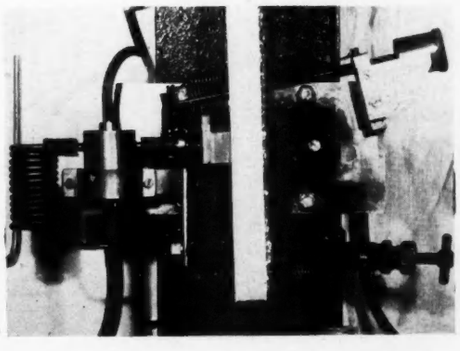
(*c*) that the specimen should be of as simple a form as possible (for ease and accuracy of machining),

(*d*) that provision should be made for efficient end clamping.

These conditions are met by the specimen shown mounted in the lower clamp in Fig. 4.

* "Elastic Limits of Iron and Steel under Cyclical Variations of Stress," by L. Bairstow, *Phil. Trans. Roy. Soc.* A., vol. 210, page 35 (1910); "Elastic Hysteresis in Steel," by F. E. Rowett, *Proc. Roy. Soc.*, vol. A89, page 528 (1914); "Elastic Hysteresis in Crankshaft Steels," by S. F. Dorey, *Proc. Inst. Mech. E.*, vol. 123, page 479 (1932); and "The Practical Importance of the Damping Capacity of Metals, especially Steels," by O. Föppl, *Jl. Iron & Steel Inst.*, vol. 134, page 393 (1936).



Figs. 5 and 6 Arrangement for deflecting pendulum and measuring external moment.

The overall dimensions of the specimen are 6 in. long by ½ in. wide by 0·216 in. thick. The central "working section," 2 in. long, is milled and ground on one side to 3½ in. radius, giving a minimum thickness of 0·070 in.

## MEASUREMENT OF ANGLE $\theta$ AND MOMENT $m$

Figs. 5 and 6 show the arrangement used for deflecting the pendulum and measuring the corresponding external moment $m$. A plate P is arranged to swing about an axis passing through the mid-point of the unstrained specimen. Accurate movement of this plate is accomplished by rotation of a micrometer screw to which it is coupled by a ball-ended rod. The pendulum bar is coupled to the plate by a load measuring unit U which may, for the time being be taken as a spring balance with remote load indication. Provided this load measuring unit is sufficiently stiff we may assume that the deflection of the pendulum bar is the same as that of plate P and hence may be read from the micrometer screw.

As regards the design of the load-measuring unit, it should be borne in mind that the theory of the machine is based on reducing the original linear part of the moment—angular deflection curve, and hence we must still face the problem of measuring the extremely small moment differences which make up the hysteresis loop. The design of a sufficiently sensitive and stable load measuring unit (the total external moment range of the completed apparatus is only about 0·2 lb. in. reading to $\frac{1}{5000}$ part of this) proved to be the most difficult problem in the development of this whole apparatus, and several different systems were tried before a satisfactory scheme was finally evolved.

The preliminary requirements of static sensitivity are met by the simple pneumatic system shown in Fig. 7. Air, from a supply at about 4 lb. per square inch, is fed through a choke to a small sharp-edged jet fixed to plate P (Fig. 5) and impinges on the pendulum. The gap $g$ between the jet and the pendulum is small compared with the jet diameter. Under these conditions, the force exerted by the jet on the pendulum equals the product of the jet pressure $p$ and the jet bore area, this being easily checked by direct calibration. Pressure $p$ is controlled by the relative values of the choke area and the jet outlet area, and is indicated on a simple water manometer. Consideration of this system will show it to be statically self-balancing, for if pressure $p$ does not give static equilibrium of the pendulum, then the pendulum will move, changing gap $g$, and so changing pressure $p$ until a condition of equilibrium is attained. Applying numerical values to this reasoning it is found that the preliminary conditions of sensitivity stated above are easily met.

A further requirement of any practical measuring system is that any oscillation that may occur should die out as rapidly as possible. Even with a simple elastic spring balance this would be a major difficulty since the system of pendulum and spring balance would have negligible damping, and the inclusion of any damping device such as a dashpot would cast immediate doubt on the observations of the specimen damping capacity. With the pneumatic system of Fig. 7. the position is even worse, as a study of the dynamics of the system shows it to be inherently unstable, i.e., oscillations once started will increase in amplitude. This was found first by experiment and is due to the fact that changes in pressure $p$ always lag behind the corresponding changes in gap $g$.

This difficulty has been overcome by the more complex pneumatic system of Fig. 8. Here a variable inlet jet, impinging on a spring bellows unit, is used instead of a fixed inlet choke. Owing to the action of choke R and the bellows and manometer capacity, the pressure difference $p$-$p^1$ and hence the bellows deflection, is related to the rate of increase of pressure $p$. This causes a corresponding variation in the inlet jet area, and the overall effect, when the various constants of the unit are properly proportioned, is to introduce, to the relationship between pressure $p$ and the jet gap $g$, a term dependent on the pendulum velocity. This leads to the desired damping out of any oscillation of the pendulum, although the effect is rather slow and about a minute must be allowed for the readings to settle at each observed point.

The main units of the pneumatic system are also shown in Fig. 6. The outlet jet, mounted on an angle bracket fixed to plate P (Fig. 5), impinges on the surface of a small L-shaped block screwed to the pendulum. A stop-nut which engages with the upper part of this block prevents excessive swinging of the pendulum. The brass cylinder (middle left) houses the bellows unit, while the copper worm (extreme left) forms the choke R (Fig. 8).

## STATIC TESTS ON MILD-STEEL SPECIMENS. (SPECIMENS (1) AND (2).)

Static tests in the sense of being non-cyclic, have been carried out on two annealed mild-steel specimens, the object being to determine the departure from true linearity in the stress-strain diagram of this material. The results obtained are consistent and it is concluded that a reasonable standard of accuracy has been attained. The quantity initially measured in these tests is the moment difference $\Delta m$ from true linearity in the moment-angular deflection diagram of the specimen. The results obtained are plotted logarithmically in Fig. 9. Up to a critical stress (in the region of 10 tons per square inch) the departure from linearity occurs instantaneously with the application of the corresponding deflection, and, in the logarithmic plot of $\Delta m$ – deflection $\theta$ a straight line relationship is obtained for this region.

Above the critical stress a time factor enters into the observations and the logarithmic plot of $\Delta m$ curves upwards. The nature of the time dependent readings is shown in Fig. 10. Immediately on application of the appropriate angular deflection $\theta$, reading $\Delta m_1$ is obtained. This rises for some time until a steady reading $\Delta m_t$ is finally reached. The time interval T varies from about 3 minutes for stresses only slightly above the critical to about ½ hour for the highest stresses reached in these tests. It might at first be thought that the readings $\Delta m_1$ are possibly an extrapolation of the readings obtained below the critical stress, but this is not found to be the case.

The readings quoted so far refer to the moment difference from linearity for the whole specimen,

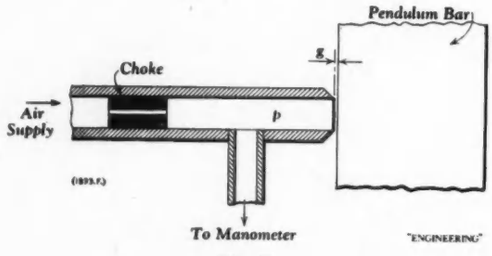



Fig. 7.

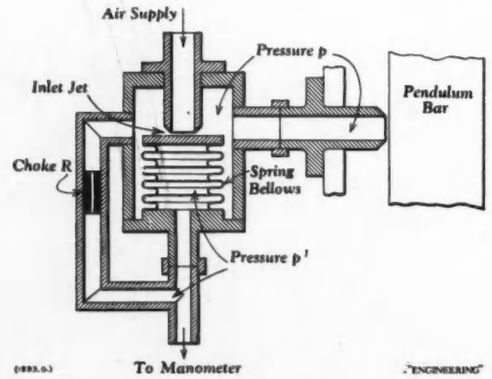



Fig. 8.

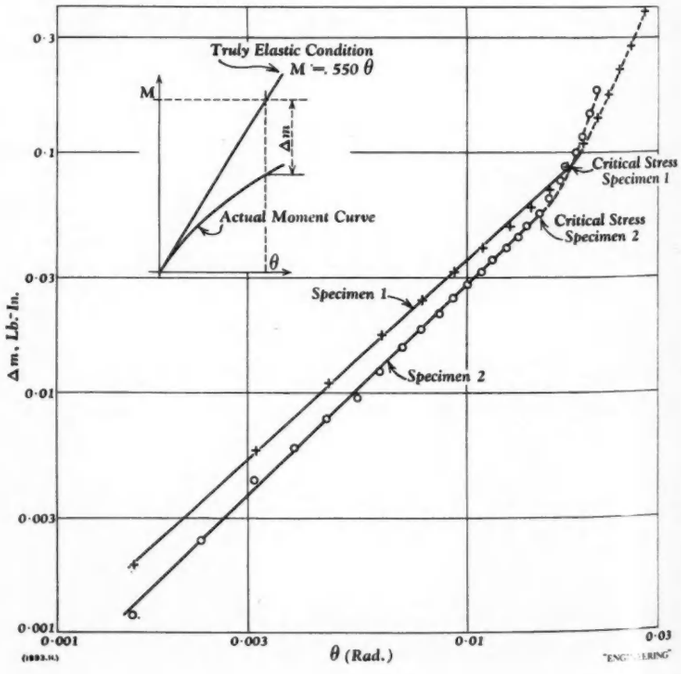



Fig. 9.

but the corresponding stress departure from linearity in a tensile test of the same material is of more general interest. If it can be assumed that this stress difference $\Delta f$ is the same for both tension and compression then, as is shown later, $\Delta f$ is given by an expression of the form

$$\Delta f = a\,\Delta m + b\,\theta\,\frac{d(\Delta m)}{d\theta} + C\,\theta^2\,\frac{d^2(\Delta m)}{d\theta^2},$$

where the coefficients $a$, $b$, $c$, etc., depend on the stress distribution and hence the geometrical form of the specimen. An application of this analysis to the experimental readings obtained below the critical stress gives the results shown in Fig. 11.

## UNI-DIRECTIONAL HYSTERESIS LOOPS ON MILD STEEL. (SPECIMEN (3).)

Specimen (3), which had been machined and annealed along with specimens (1) and (2), was subject to a series of uni-directional cyclic bending tests of increasing amplitude up to about 20,000 lb. per square inch maximum stress. The hysteresis loops obtained directly from the apparatus are shown in Fig. 12. These were taken in two runs – the first set up to 10,000 lb. per square inch and the second set from 12,000 to 20,000 lb. per square inch, two days later. The general procedure was to record moment readings round each loop until steady conditions were obtained. This occurred from the first cycle for the low stress values and varied up to about four complete cycles for the highest stresses recorded. The actual plotted points have been shown for one loop, being numbered in the order in which they were obtained.

Fig. 13, line (*a*) shows the result obtained when these loops are analysed to give the resulting damping coefficients,

i.e., Damping coefficient =

$$\frac{\text{Energy loss in hysteresis/cycle}}{\text{S.E. in the specimen at max. stress of cycle}}.$$

With the exception of the first three points, at which the hysteresis loop is very narrow and hence difficult to measure accurately, the results indicate a relationship of the form

$$\text{Damping coefficient} \propto \text{stress}^{0.84},$$

or

$$\text{Energy loss/cycle} \propto \text{stress}^{2.84}.$$

Line (*b*) in this same diagram shows the equivalen damping coefficient for the same material subject to a pure tensile test. The analysis by which this result is obtained is as follows:

Let $D_F$ = observed damping coefficient of the whole specimen when the maximen stress is F.

$d_f$ = damping coefficient of the same material in a pure tensile test of maximum stress $f$.

$f = \rho F$.

and let the stress distribution be defined by a function $\nu$, such that

$\nu\,d\rho$ = volume of material in the stress range $\rho F$ to $(\rho + d\rho)\,F$.

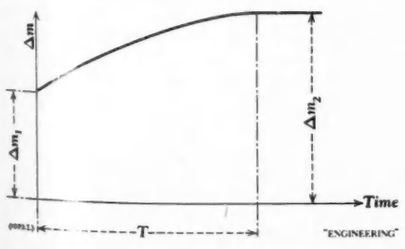



Fig. 10.

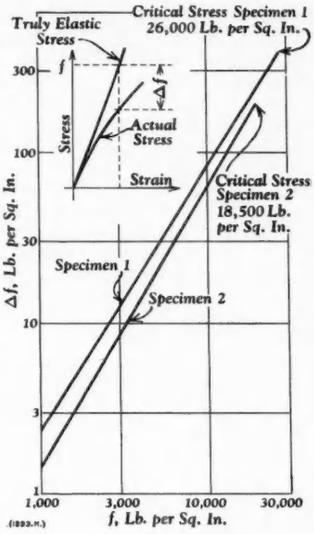



Fig. 11.

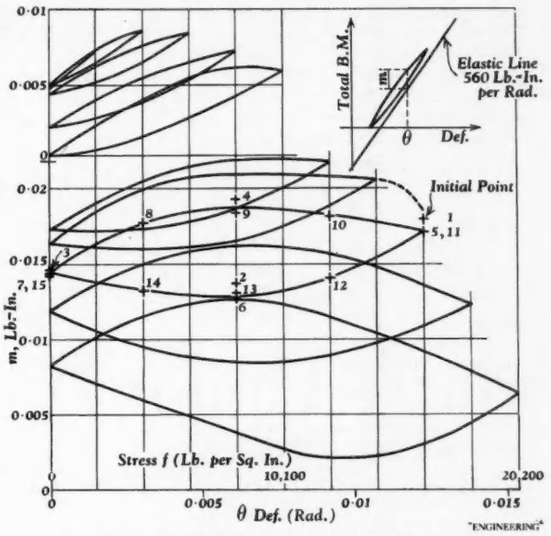



Fig. 12 Uni-directional hysteresis loops: specimen (3) – annealed mild steel.

With this notation and assuming Young's Modulus E to be practically unaltered by the hysteresis loop.

Total energy loss per cycle

$$= D_F \int_0^1 \frac{\rho^2 F^2}{2E}\,\nu\,d\rho. \quad \text{— by definition,}$$

$$= \int_0^1 d\rho_F\,\frac{\rho^2 F^2}{2E}\,\nu\,d\rho. \quad \text{— by integration.}$$

Thus

$$D_F \int_0^1 \rho^2\,\nu\,d\rho = \int_0^1 d\rho_F\,\rho^2\,\nu\,d\rho.$$

The right-hand integral can be expanded as

$$d_F \int_0^1 \rho^2\,\nu\,d\rho - F\,(d')_F \int_0^1\int \rho^2\,\nu\,d\rho\,d\rho + F^2\,(d'')_F \int_0^1\int\int \rho^2\,\nu\,d\rho\,d\rho\,d\rho \ldots \text{ etc.},$$

where primes indicate differentiation with respect to F.

Hence

$$D_F = a_1\,d_F - a_2\,F\,(d')_F + a_3\,F^2\,(d'')_F \ldots \text{ etc.},$$

where

$$a_1 = 1 \quad a_2 = \frac{\int_0^1\int \rho^2\,\nu\,d\rho\,d\rho}{\int_0^1 \rho^2\,\nu\,d\rho},$$

$$a_3 = \frac{\int_0^1\int\int \rho^2\,\nu\,d\rho\,d\rho\,d\rho}{\int_0^1 \rho^2\,\nu\,d\rho} \ldots \text{ etc.}$$

By linear addition of the successive differentials of both sides of this equation the damping coefficient in pure tension is obtained as

$$d_F = D_F + b_2\,F\,(D')_F + b_3\,F^2\,(D'')_F \ldots \text{ etc.},$$

where

$$b_2 = \frac{a_2}{1 - a_2}. \quad b_3 = \frac{-a_3 + (a_2 - 2a_3)\,b_2}{(1 - 2a_2 + 2a_3)} \ldots \text{ etc.}$$

Due to the fact that the derivatives of the observed function D are of importance in this analysis, it can only be accurately applied to cases where the observations can be expressed in some simple form.

A particular case of interest is where

$$D_F = F^n.$$

then

$$d_F = F^n + b_2\,F\,n\,F^{n-1} + b_3\,F^2\,n(n-1)\,F^{n-2} \ldots \text{ etc.}$$

$$= [1 + n\,b_2 + n(n-1)\,b_3 \ldots]\,D_F.$$

This same general procedure can be applied to other problems in which the observed result is essentially an integral of the quantity being measured. It has been used in an earlier section of this article for estimating the departures from true linearity in the stress strain diagram. Another application which has been worked out is the deduction of the usual yield point and work hardening in a material from observations of the plastic bending of a beam of arbitrary cross section (but symmetrical about the N.A.) and subject to a uniform bending moment. This, however, assumes that the required functions are the same in tension and compression which may be doubtful.

## CONCLUSIONS

From the consistent nature of the results obtained in these tests, it is concluded that this apparatus performs in a satisfactory manner the tests for which it is intended. In view of the small number of actual observations made no definite conclusions can as yet be drawn about the fundamental nature of the hysteresis phenomenon. There is, however, one aspect of these few results which is worthy of note. If it is postulated that the effects of non-linearity in the stress strain curve, and hysteresis, are due to the failure of a very small proportion of the material at abnormally low stresses, and if the

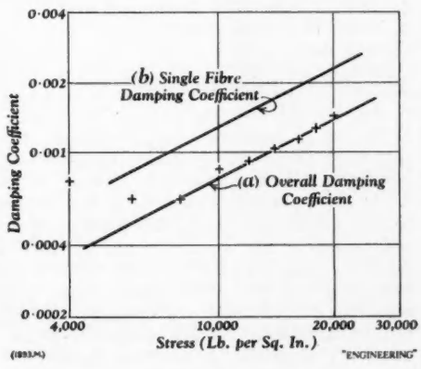



Fig. 13.

proportion of material failing in the range of stress $f$ to $f + df \propto f^K$ it is easily shown that

the departure from true linearity $\propto f^{K+2}$
the hysteresis energy loss/cycle $\propto f^{K+3}$
and the damping coefficient $\propto f^{K+1}$

The results of the three tests carried out give

| | | |
|---|---|---|
| Static tests .. | Specimen 1 | $K = -0{\cdot}44$ |
| | Specimen 2 | $K = -0{\cdot}34$ |
| Hysteresis test .. | Specimen 3 | $K = -0{\cdot}16$ |

These indices, although somewhat variable, are all negative, indicating that the function $f^K$ has a high value at low stresses and falls as the stress increases. This reasoning, which contradicts any single idea of progressive yielding, would apply to all damping test results giving the energy loss varying by less than the cube of the stress amplitude.

### ACKNOWLEDGEMENTS

The work described in this article was started in the James Watt Engineering Laboratories of the University of Glasgow under the supervision of the late Professor Gilbert Cook, and is being continued under Professor James Small.

# DIESEL ENGINE PERFORMANCE

## NOISE AND SMOKE REDUCED AND POWER INCREASED BY SECONDARY FUEL

Two papers dealing with different aspects of – and the advantages to be gained by – introducing a secondary supply of fuel into the intake air of a compression-ignition engine, were presented at a meeting of the Institution of Mechanical Engineers held in London on January 8.

### NOISE REDUCED

The first, "An Experimental Investigation into the Effect of Fuel Addition to Intake Air on the Performance of a Compression-Ignition Engine," by Mr. W. T. Lyn, M.Sc. (Eng.), had been prepared as a result of a programme of research into the means of reducing combustion noise and engine roughness. The investigation was carried out in the laboratories of the British Internal Combustion Engine Research Association on a four-stroke single-cylinder commercial engine of 5 in. bore and 6·25 in. stroke, which could be fitted with a Ricardo Comet Mark II or Mark III combustion chamber, and on an open-chamber engine of 4½ in. bore and 5¾ in. stroke. A variety of fuels were sprayed into the intake stream and in most cases pool gas oil and benzene were used as the main fuels. In many cases engine noise was considerably reduced by the introduction of fuel in the air intake and it was found that the proportion of fuel required by the intake air decreased with increasing load when smooth running was maintained.

A noise reduction of two decibels was recorded, based on the peak value, for the Comet Mark II engine running at 1,200 r.p.m. and 70 lb. per square inch b.m.e.p., as compared with the engine running without the intake spray.

During preliminary tests it was also observed that cold starting was easier and while fuel consumption in the neighbourhood of the rated load varied little from that on the standard engine it deteriorated rapidly below this figure and showed some improvement above.

### BUNKER FUEL

Mr. Lyn said that a shortening of the combustion delay period by the use of intake spray, shown by his preliminary studies, suggested the possibility of using fuel of low ignition quality as the main charge. As the use of bunker fuel for the engines of oil tankers had recently aroused considerable interest he decided to investigate its behaviour when used as the fuel for a small high-speed engine. Tests were therefore made using Ordoil (a fuel of Curaçao origin) for the main fuel and paraffin in the spray. When running on Ordoil alone severe knocking occurred but immediately the spray was introduced smooth running commenced. The ignition delay was cut from 20-25 deg. crank angle to 10 deg. and the brake thermal efficiency obtained was better than that obtained when running the engine on pool gas oil.

In experiments with different combustion-chamber heads pool gas oil was used as the main fuel and paraffin for the spray. Improvement in running was noticeable in the case of the Mark II and Mark III chambers and the former also showed a worthwhile fuel saving in the high load range, while the change in performance of the engine fitted with an open chamber was only slight.

In his conclusions, Mr. Lyn said that the general theory which could be formulated from his investigations was as follows. When fuel was introduced with the intake air it underwent slow oxidation of the chain-reaction type accompanied by heat release and formation of partially-oxidised products of combustion during the compression stroke. The compression curve was raised during the later part of the stroke owing to heat release and increase in the number of molecules present while the active partial products of combustion shortened the ignition delay of the main charge. Thus the characteristic rapid pressure rise of normal Diesel operation disappeared and a smooth pressure diagram was obtained with consequent absence of combustion noise.

Near the end of the compression stroke and prior to the injection of the main fuel, the air-fuel mixture was approximately homogeneous. The fuel-air ratio was well below the ignition limit; the mixture could only undergo slow oxidation and could not propagate flame. Hence the products of partial oxidation did not proceed to complete combustion except for those parts that came directly into the flame front of the main fuel. The rest of them left the engine with the exhaust gases and this wastage contributed to the loss of thermal efficiency. The loss was the greater under part-load conditions when the duration of flame of the main injection was shorter, and possibly the region of the combustion chamber traversed by the flame was smaller.

On the other hand, the slow oxidation of the inlet spray sensitised the air, and the period of combustion of the main charge was somewhat reduced, with consequent improved combustion. The result of these two opposing factors was that with the use of the inlet spray the overall thermal efficiency was impaired at light load but improved at high load.

There were several possibilities of practical applications arising from the scheme of introducing fuel into the intake air. The most interesting aspect was that any fuel, irrespective of its ignition quality, could be operated successfully in a compression-ignition engine without suffering from high maximum pressure and rough running when a small quantity of high-ignition fuel was used as intake spray.

In times of emergency, when the conservation of good quality fuel was essential, such a scheme might prove very useful. Secondly, it provided a means of suppressing combustion noise and engine roughness. Unfortunately, combustion noise was most noticeable under light load conditions, which, as shown previously, imposed a penalty on fuel consumption. Finally, the scheme offered a way of increasing the output of the engine for a given allowable exhaust condition with an accompanying increase in thermal efficiency.

### LESS EXHAUST SMOKE

Mr. D. Royle, B.Sc. (Eng.), presented the second paper on behalf of his co-authors (the late Mr. L. D. Derry, Dr. E. M. Dodds, and Dr. E. B. Evans – all of the Esso Development Company), entitled "The Effect of Auxiliary Fuels on the Smoke-limited Power Output of Diesel Engines." He began by stating that the production of exhaust smoke was one of the principal factors limiting the power output of Diesel engines, and in the case of motor-vehicle engines this was particularly true. Regulations existed for the control of exhaust smoke emitted from Diesel engines, and in practice a smoke density of 0·15 (corresponding to 29 per cent. smoke) was usually regarded as a satisfactory minimum.

The authors were aware of the fact that operating conditions and fuel properties both influenced the amount of smoking, and in the light of earlier work it was thought that rather more of the air present in the combustion chamber could be utilised. Only 65 to 70 per cent. of the available air was normally used in the Diesel engine, in contrast to the petrol engine, which used practically 100 per cent. Their investigations were concerned with the use of volatile auxiliary fuels, such as petrol, as means of improving the air consumption.

During the course of these investigations, auxiliary fuels were supplied to the engine in three different ways: by aspirating directly into the air inlet manifold; aspirating through a vaporiser into the air-inlet manifold; and by injecting directly into the engine cylinder.

The result of their work, which was carried out on a typical automotive high-speed six-cylinder Diesel engine, demonstrated that substantial advantages could be gained by reducing the quantity of Diesel fuel injected at full load and aspirating into the engine a weak mixture of air and a vaporised fuel. In this way an increase in power at any given speed could be obtained from the engine without increasing the density of the exhaust smoke above that permissible for the engine operating under standard conditions, or alternatively, for the same power output the smoke level could be substantially reduced. Better utilisation of the available air was obtained by preliminary mixing of the volatile fuel before injection of the main Diesel-fuel charge.

When using 75 per cent. of the normal maximum Diesel-fuel input on the engine under test, with petrol aspiration up to the limit imposed by the normally accepted smoke limit, a power increase of just over 20 per cent. was obtained, and the quantity of air consumed was 80 per cent. compared with 68 per cent. for normal operation. An increased overall engine efficiency of about 4 per cent. was also obtained. Used in this way petrol could be burnt at a compression ratio of 16 to 1, which was much in excess of the

compression ratio normally used for this type of fuel. To obtain such an improvement it was necessary to ensure that the auxiliary fuel was completely vaporised, and while this could be achieved by raising the temperature of the inlet air it only resulted in reducing the volumetric efficiency.

The maximum smoke-limited power outputs were obtained when aspirating fuels of higher octane (lower cetane) rating. The reason for this was not entirely clear but the authors thought it might be because the high cetane-number auxiliary fuels ignite too early and initiated the combustion of the main charge before it could mix thoroughly with the air in the combustion chamber. Increase in smoke-limited power was restricted on the engine used, particularly with the lower octane number fuels, by the occurrence of knocking when the air/fuel ratio was lower than, say, 50 to 1 at high speeds or 65 to 1 at low speeds.

### BI-FUEL SYSTEM PROPOSED

In the case of engines operating at a constant and fairly high speed, the authors stated that the maximum gains in power could be obtained by introducing the auxiliary fuel at powers above 75 per cent. of the full-load rating. In the case of the automotive Diesel engine, it would be an advantage to have a high maximum speed output, but would be an even greater advantage to increase the maximum torque. When aspirating ordinary petroleum spirit from 75 per cent. of the normal full power output, the gain in power at maximum torque was only 5·5 per cent. compared with 20·5 per cent. at maximum speed, the power at maximum torque being limited by combustion knock, and the knock becoming noticeable at air/petrol ratios less than about 65 to 1. By interpolation of the results obtained with the maximum power limited by different settings of the Diesel fuel stop, it was estimated that by restricting the power on Diesel fuel alone to about 85 per cent. of the normal maximum, it would be possible to obtain a power increase of about 12 per cent., without combustion knock or increased smoking, at all speeds between that of maximum torque and maximum power. It was thought that increases of this type might be sufficiently attractive to encourage automotive-engine manufacturers to adopt a bi-fuel system.

The advantages to be gained in extra power and economy, coupled with reduction of exhaust smoke, they thought, might well make such an adaption attractive, particularly as the fuel costs per brake horsepower per hour of the two systems were almost identical.

# THE WEAR OF ELECTRIC RAILWAY ROLLING STOCK

## EXPERIENCE ON LONDON TRANSPORT

When rolling stock containing new features is introduced on a railway system, although mention may be made in the technical journals of those which are intended to facilitate and reduce the cost of maintenance, their success is rarely revealed, for the reason that a long time is necessary to determine any savings that have been achieved. In a paper read before the Institution of Locomotive Engineers on Wednesday, January 20, Mr. A. W. Manser, Chief Mechanical Engineer (Railways), London Transport Executive, therefore summarised experience obtained on that system with the idea of showing the trends in design that have proved beneficial in reducing maintenance costs. He dealt, in particular, with the wearing parts of bogies, including tyres, wheel centres, axles, axleboxes suspension spring systems and frames, as well as with collector shoe and brake gear, bolsters, motors, draw and buffer gear, sliding doors and traction and brake control equipment.

### WHEELS AND AXLES

On the London Transport system 4,050 vehicles operate some 585,000 car-miles per day, and the movements of pneumatic doors total 4,000,000 per day. Enormous variations in tyre or wheel wear have been noted, ranging from the 36-in. diameter motor tyres used on the earlier District stock, which require re-profiling every 30,000 miles, to the 30-in. diameter trailer tyres on a Piccadilly-line car which have run over 800,000 miles without attention and the profile of which was not badly out of gauge at the end of that time. Although a number of different types are in use the present practice is to employ cast spoked wheels on new rolling stock. The reason is that the forged disc centres are prone to fatigue cracking after long service. After the wheel centres have been re-tyred a few times the outer diameter is no longer truly round and the distortion must be corrected by skimming up the surface. This prevents the tyres from being bored to a standard size, each tyre having to match the diameter of the particular centre for which it is intended.

For many years axles for London Transport rolling stock have been made from steel with an average composition of carbon 0·3 per cent., silicon 0·23 per cent., manganese 0·73 per cent. and sulphur and phosphorus not more than 0·04 per cent. each, which is heat treated to give a tensile strength of 40 to 45 tons per square inch. In the latest designs sudden changes of section in either direction are avoided, the axles are given a ground finish over their whole length and are cold rolled over the wheel seats to increase fatigue resistance. Axles with an original diameter of 6·5 in. are reground to 6·45 in. when the wear has reached about 0·025 in., that is normally after 600,000 miles have been run. A second re-grinding takes place after a similar mileage. Bronze castings are used as suspension bearings as this material is more easily keyed to the shell, is more resistant to hammering and picks up dirt less readily. They will generally run 40,000 to 50,000 miles before they have to be changed on account of wear. The later types of axle are all fitted with double-row parallel-roller bearings, which have given good service with very little attention.

Two main types of axlebox are used: the cast steel box, which is entirely satisfactory in service but is rather heavy and liable to some distortion when welding in new horn liners; and the fabricated box, which has fallen into disrepute owing to the high cost of maintenance resulting from poor welding technique and a lack of stress relieving in manufacture.

All London Transport rolling stock is fitted with laminated main side springs and with auxiliary side springs of either the rubber or steel helical types. Very little trouble has been experienced with the various types in use. Steel auxiliary side springs are more prone to breakage than main leaf springs, owing to the fact that the movements of the hanger other than in the vertical plane result in the spring being bent as well as compressed. The inter-leaf friction of the main spring also causes the auxiliary to be subject to relatively more continuous variation of deflection. The main result of attempts to avoid subjecting the auxiliary springs to bending by mounting them with knife-edged washers has been to cause wear on the shank of the spring hanger bolt.

### BOGIES

The present practice with bogie frames is to use all-welded side frames coupled together by welded transom plates and headstocks, which are, however, secured to the side frames by riveting. This design enables the racking stresses to be withstood without fracturing and enables replacement to be effected more quickly than in an all-welded structure. Another advantage is that stress-relieving after welding, which is now recognised as being necessary for parts which are subject to racking and alternating stress, can be carried out in a smaller furnace.

The brake rigging on the bogie is subject to a great deal of wear from vibration. All the brake-beam connections should therefore be protected by bushes with a taper head and by sleeving. An even better solution is that adopted on the later rolling stock, on which individual brake units, incorporating cylinder, piston, lever, slack adjuster and hand adjusting wheel are all combined in one dustproof and greaseproof container. The only rigging consists of a brake-block hanger designed to follow up automatically and such interconnection as is essential for hand-brake purposes. Recently it has been found possible to use a non-metallic brake block without a cast-iron shell, provided adequate side guiding is available for the brake head. The attraction of this innovation is that the life of the block is increased out of proportion to its cost.

For many years the traction motors, of which there are some 5,600 of seven basic designs in use, have been equipped with roller bearings, thus cutting down certain bearing trouble and reducing the cost of lubrication. The necessity to use ventilated motors contributes to the wear of the bush gear and commutator, and in general it is found necessary to re-slot the micas and turn the commutator after 200,000 miles and to re-condition the brush boxes after 500,000 miles. Trials are now proceeding with motors insulated with silicone materials in the hope that owing to the higher temperatures which can then be tolerated totally-enclosed motors can be employed.

### SLIDING DOORS

The most serious wear of sliding-door tracks occurs near the rollers or hangers and in the closed position. It is due to the constant fretting all the time the vehicle is in motion, as lateral freedom is essential to avoid the door becoming "bound." The pneumatic door engines of the latest pattern run for eight years without alteration other than periodic grease-gun lubrication of the bearings. Difficulty has been experienced in designing an arm for the door engine which will withstand service conditions indefinitely, but the solution seems to be to attach the arm to the engine with a rubber mounting.

The door-closure proving circuit of an eight car train may contain as many as 96 interlock switches in series. An exceptionally high standard of reliability is therefore necessary, but a combination of contact materials has recently been found which promises to reduce wear, although frequent inspection remains necessary.

# MEASURING THE DUST CONTENT OF BLAST-FURNACE GAS

## CONTINUOUSLY-RECORDING PHOTO-ELECTRIC METER

For measuring continuously the dust concentration of blast-furnace gases, a photo-electric recording dust meter has been developed under the guidance of the British Iron and Steel Research Association, and is now being manufactured by Radiovisor Parent, Limited, 1, Stanhope-street, London, N.W.1. In comparison with gravimetric methods of measurement, which must necessarily take place after the particles have passed through the plant, the photo-electric method of measurement makes it possible to determine whether a uniform dust concentration has existed over the set measuring period, or whether the deposit has been caused by a few short periods of high dust concentration resulting from intermittent failure or overloading of some sections of the cleaning plant.

The Bisra photo-electric dust meter monitors the gases at a chosen point in the main ; it may be calibrated in conjunction with standard gravimetric measurements, and to suit site conditions. The equipment enables an alarm to be sounded immediately a predetermined dust level is exceeded.

The instrument, which employs the light-scattering technique, comprises four main components :

(1) The sampling chamber, in which are installed photo-electric cells, the light source, and an optical system.

(2) A thermionic valve amplifier, together with its stabiliser, power supplies, and setting-up controls.

(3) A 7-in. diameter indicator-relay meter incorporating a small contactor for connection to an alarm system.

(4) A continuous 3½-in. wide strip recorder.

The light source and optical system in the sampling chamber give a parallel beam of light of uniform intensity which is projected through the actual viewing chamber on to a light trap specially designed to prevent secondary light radiation. The viewing chamber consists of a series of baffles to maintain the cylinder of light, and a glass cylinder with gas-tight joints: on the outside of the cylinder are three photo-multiplier cells. The complete unit is suitably insulated to reduce heat losses.

The output-leads from the photo-multiplier cells and the high-tension and projector lamp supplies are brought to a multiple-point insulated plug, from which a flexible cable is taken to the electronic control panel. This incorporates thermionic valve amplifiers and their associated power supplies : care is taken to ensure the maintenance of a consistent supply for the high-tension and low-tension voltage feeds. Controls are provided for setting the instrument to zero. The output-lead from the panel is taken to a 7-in. diameter flush-mounted meter fitted with a small contactor to operate the alarm. This is energised by setting an auxiliary pointer on the instrument dial to a predetermined reading, and when the indicator needle coincides with this point a circuit to the contactor control coil is completed.

When clean air is introduced into the viewing chamber, a minimum of light scatter takes place, and a minimum current is passed by the photo-cells. The output from the electronic amplifier is " backed off " so that in this condition a zero reading is shown on the recorder and meter. Any increase in light scatter due to dust particles suspended in the gas results in an increase in the photo-multiplier current, with a corresponding deflection of the needle of the indicator meter.

In use, the blast-furnace gas is taken from the main, raised above dew point by preheating it with steam coils, and fed through the viewing chamber. After recording the dust concentration it is then either injected back into the gas main by an impeller, or exhausted to atmosphere. To prevent aggregation of the particles, the design of the sampling tube incorporates smooth bends, gate-type valves, and a thin-walled receiving tube. Gas velocities in the main stream are measured, and the flow rate in the sampling by-pass controlled, by an orifice plate : this ensures that a correct comparative reading of the dust concentration is obtained.

The equipment has undergone prolonged trials under the guidance of the British Iron and Steel Research Association at various steelworks, and the figures obtained proved consistent when checked by gravimetric estimates. The results showed sharp increases in dust concentration when part of the cleaning plant was closed down.

# GAS-TURBINES AT BEZNAU POWER STATION*

## OPERATING EXPERIENCE AT THE LARGEST GAS-TURBINE POWER STATION

*By E. A. Kerez* †

In Switzerland practically all the electric power consumed is generated in hydro-electric power stations. The latest records available are those for the hydrographic year 1951-52, which dates from October 1 to September 30 to include a complete winter season, and these show that the total consumption during that period was 13,250 million kWh. Of this total, 99 per cent. was obtained from the Swiss water-power stations.

After exceptionally dry summers the storage lakes may not be full when the winter starts or during a long and cold winter the capacity of these lakes may have been consumed before the spring is due and these are the times when power is required from other sources. Two such sources are available, either we may buy power from the neighbouring countries or generate it ourselves in thermal power stations. In the above-mentioned period, 541 million units were actually imported, being some 4 per cent. of the total demand, but in order to ensure continuity and independence of such imports, thermal power stations have been in existence all along, their prime movers being either steam turbines or Diesel engines and, for a number of years, also gas turbines.

It was early in 1939 that the first gas turbine for driving an alternator to be installed in an electric generating station was completed, namely, the 4,000-kW set ordered by the city of Neuchâtel. It is a standby plant for emergency use only and is, therefore, of very simple design and consequently its thermal efficiency is modest.

During the war years 1939-45, few and only small water-power plants were built in Switzerland because both labour and material were scarce. There was, therefore, a severe shortage of electric power when the war came to an end in 1945 and when trade began to revive. The North Eastern Swiss Power Supply Company (the N.O.K.) who, incidentally, supply about one-sixth of the total power consumed in Switzerland, investigated what thermal power plants they could build to solve this problem in the minimum of time. Their aim was to build a power plant that would conform to the following conditions :—

(1) To have a total installed capacity of 40,000 kW and to generate power at costs not exceeding those of hydro-electric storage plants and intended for operating between 1,000 and 3,000 hours per winter.

(2) The machines to be suitable for quick starting and to be easy to operate and maintain.

(3) The plant to be available for commercial operations as quickly as possible.

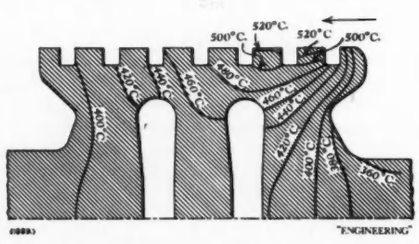
For this purpose they investigated proposals with different prime movers, namely, steam turbines, Diesel engines or gas turbines and, in June, 1946, decided to install two Brown Boveri gas-turbine sets and to build the power station at Beznau.* At that time Brown Boveri had a 10,000-kW gas-turbine unit under construction for a plant in Lima, Peru, and by adapting these designs for a set to operate under the climatic conditions that prevail at Beznau between November and March, when the mean air and cooling water temperature are each 5 deg. C. (41 deg. F.), an output of 13,000 kW can be obtained.

This solution was accepted by the purchasers because it made it possible to complete the first unit and have it ready for running as early as December, 1947. This promise was held and the second set to provide the remaining 27,000 kW was ready for running in January, 1949.

It should be remembered that at the time the two gas-turbine units were ordered for Beznau, Brown Boveri only had nine gas-turbine sets

* Paper presented at a meeting of the Diesel Engine Users Association, in London, on Thursday, January 21, 1954. Abridged.

† Brown Boveri & Co., Ltd., Baden, Switzerland.




**Temperatures in the rotor body of a gas-turbine where the admission temperature is 600 deg. C. (1,112 deg. F.). The rotor face at the inlet end is cooled with air entering at a temperature of 320 deg. C. (610 deg. F.).**

* This station was illustrated and briefly described in ENGINEERING for November 13, 1953, page 611.

of similar design on their order books. Of these nine machines only one was in service, the 4,000-kW set at Neuchâtel, and this was only a standby unit for emergency use. A 10,000-kW set had then just been completed at the maker's works and a series of interesting tests successfully concluded. However, operating experiences with gas turbines working with a temperature of 600 deg. C. (1,112 deg. F.) or more for extended periods were not available. There were then some 40 Houdry sets which had already been in successful industrial operation for several years, but as the gas turbines of these units are designed only for 510 deg. C. (950 deg. F.), this experience was only of relative importance.

## FAULTS AND REMEDIES

It was, therefore, only to be expected that a plant incorporating the first gas-turbine units ever built for such big outputs and for burning a heavy fuel oil, would require several problems to be solved before satisfactory commercial operation was achieved. In the following, such occurrences and also the means adopted to overcome these difficulties are chronologically recorded.

(*a*) After a period of approximately 300 running hours three blades broke in the third stage on the high-pressure gas-turbine rotor of the 13,000-kW set. Investigations showed the cause of the failure to be due to intra-crystalline cracks originating at the notch at the blade foot.

The accompanying diagram shows the temperature distribution in a gas-turbine rotor with an inlet temperature of 600 deg. C. (1,112 deg. F.) when the face of the rotor on the inlet side is cooled with air at 320 deg. C. (610 deg. F.). The temperature curves in this figure show that the highest temperature occurs not at the first row of blading but in front of the second and third and that it amounts to approximately 530 deg. C. (985 deg. F.). This explains why the damage took place in the third row and not in the first as would be expected. The blade foot construction at that time corresponded to that successfully employed in our steam turbines and likewise also successfully applied in the many gas turbines for the Houdry sets and Velox boilers. The increase in inlet temperature to 600 deg. C. (1,112 deg. F.) showed, however, that this design was not suitable for such a high temperature. We, therefore, made the blade foot considerably stronger and improved the design taking these findings into account. The solution is satisfactory as has since been proved in operation.

(*b*) After about 2,400 running hours the rotor of the low-pressure gas turbine of the 13,000-kW set suddenly started to vibrate. Inspection disclosed a crack in the bottom of the blade slot, once again in the third row of the blading. Further investigations showed that here also was an intra-crystalline crack resulting from the notch effect of the blade slot. We have changed the construction to remove this notch effect and also the metal alloy used.

(*c*) At the end of the winter 1948-49, the second after setting Beznau into operation, we experienced trouble due to the fouling of the medium and high-pressure compressors with a type of deposit which we had never before encountered in any of the axial blowers previously built. Why this appeared at Beznau is due to peculiar circumstances. When the wind blows from the west it passes over the surrounding forest and the power station to the exhaust stack on the far side of the building and then creates an eddy in the space between the building and the fuel tanks. In this way some of the exhaust gas is forced downwards into the inlet ducts of the low-pressure compressors. Little fouling took place in the latter. However, such a hard layer of deposit was built up in the medium and high-pressure compressors that it could only be removed by mechanical means. This hard deposit can be explained as follows.

The fuel contains approximately 2 per cent. of sulphur and the exhaust gases therefore contain $SO_2$ (sulphur dioxide) and $SO_3$ (sulphur trioxide). In the intercoolers the dew point is exceeded with air of high humidity and the resulting condensate forms sulphuric and sulphurous acids with the $SO_3$ and $SO_2$. The latter attack the copper of the cooler tubes and form copper sulphates which are soluble in water and are so carried, together with soot and occasionally also cement dust, as can occur at Beznau, into the succeeding compressors. In the course of compression the water evaporates and this material carried in the water is deposited on the blading forming a hard layer. We have overcome these difficulties by building a device into the coolers to separate the condensate before the intake to the compressor and since then we have had no further occurrences of this nature.

(*d*) We experienced considerable damage by a fire in some of the heat exchangers of the 27,000-kW set. Investigations showed that after a bad starting-up the soot deposited in the heat exchangers caught fire, because the soot became impregnated with fuel which succeeded in reaching the heat exchangers. The fire was discovered only about two hours after the plant had been shut down and, peculiarly, fire occurred only in three heat exchangers, while the remaining seven were only slightly or not at all damaged. The soot deposit was apparently unevenly distributed in the heat exchangers, thus resulting in damage to only three of them.

This experience led to the introduction of soot blowers built into the heat exchangers in order to prevent soot deposition. They employ compressed air taken from the high-pressure compressor at 8 atmospheres (100 lb. per square inch gauge) and are operated once every 36 hours when the gas turbines are running continuously; for intermittent operation of the set the soot blowers are operated before shutting down.

(*e*) Operation with heavy residual oil, as at Beznau, necessitates periodic cleaning of the gas turbines in order to remove the slag from the blading. Such a cleaning must be carried out after approximately 300 to 400 hours full-load operation. For this purpose spray nozzles are built into the inlet side of the gas turbine which enable the blades to be cleaned over their full length. The washing is carried out when the turbine has cooled down to about 100 deg. C. (212 deg. F.). According to the time available, the cooling down may be carried out with or without artificial cooling. Without artificial cooling the cooling-down time is approximately 30 hours. This can be shortened by using the starting motors to spin the turbines and compressors. The washing itself is carried out while the rotor is rotated by the starting motor. Steam from the electric boiler is first fed into the turbine to dissolve and loosen the slag. Water is then injected under pressure, still with the rotor turning. The slag is washed out of the turbine to the exhaust duct where it is carried away. It requires about two hours to wash the Beznau sets. The blades of the high-pressure rotor of the 13,000-kW set showed no sign of corrosion after 7,900 hours running time.

## DAILY OPERATION AND MAINTENANCE

A gas-turbine plant requires little attendance and it may be of interest to give a few figures concerning the operating staff needed. In Beznau the two sets are run with only three men per shift, i.e., one man for attending the sets proper and the other two for attending as necessary to any other part of the plant such as the heat exchangers, the cooling-water pumps or any other auxiliaries. For running a plant of this type and size continuously and allowing for all possibilities, such as routine maintenance, repairs, absentees, etc., the complete personnel necessary would be no more than 16 men, in other words one man per 2·5 MW of the installed capacity. These figures are in agreement with those for other plants.

As far as maintenance costs go which have been reported to us by the owners of three gas-turbine plants, and expressed in costs per kilowatt-hour generated, they differ somewhat, the highest being those experienced at Beznau. Even taking the costs experienced at Beznau, they are remarkably low, being only of the order of 0·035 Swiss cent per kilowatt-hour. In order to obtain a figure representing the maintenance costs of a gas-turbine plant over a long period, say of the order of 15 years, these should include the costs for cleaning both gas turbines and compressors, where necessary, for inspection and overhauling after a running period of, say, about 6,000 hours, further including the costs for such spare parts used at short intervals and also the replacement of such parts as may be required only after about 100,000 running hours. Allowing for all these operations and material the resulting maintenance costs for a plant like Beznau to-day represents 0·11 Swiss cent per kilowatt-hour, or 0·02*d.* per kilowatt-hour.

## CONCLUSION

The history of the practical application of the Brown Boveri gas turbine began with its employment as prime mover for pressure chargers for Diesel engines and later it was introduced as a component part of the Velox steam generator, driving the compressor for charging the combustion chamber. These applications date back about 25 years. Then came the development of the Houdry set and eventually the gas turbine was applied in several other fields, for driving generators, compressors, locomotives, etc.

The gas turbine is still in course of rapid development, as hardly 20 years have passed since we built the first machine of this kind for industrial purposes. Step by step and with great care the temperature has been raised and to-day we are in a position to build gas turbines for gas fuel for 750 deg. C. (1,380 deg. F.), while for oil firing (i.e., for burning heavy residual fuel), a limit at about 650 deg. C. (1,200 deg. F.) is set, at least for the time being.

The unit capacity for single-shaft sets with single-stage compression and single-stage combustion is to-day feasible up to approximately 15,000 kW, whereas for two-stage compression with two-stage combustion the unit capacity can be increased to about 25,000 kW. This latter figure seems contradictory when compared with the capacity of the larger set for Beznau, but only at first sight. It must be considered that the 27,000-kW unit at Beznau represents in reality the two-fold application of the L.P. elements incorporated in the 13,000-kW unit; the H.P. portion being of similar design to that of the smaller unit but correspondingly bigger and running at 3,000 r.p.m. Apart from that we must also remember that the Beznau sets are designed for an unusually low air temperature and cooling water temperature (each 5 deg. C. or 41 deg. F.), while for an ambient temperature of 20 deg. C. or 68 deg. F. the capacity would be some 10 per cent. less. Whether it will be worth while building gas turbines for still larger outputs will depend, above all, on their costs and efficiency compared with those of other prime movers, particularly the steam turbine.

# TURBINE DEVELOPMENTS

## MARINE AND LAND, STEAM AND GAS

Present-day knowledge and practice in the field of high-temperature turbine machinery – both steam and gas – and the line which future progress might be expected to follow, were described in great detail in the 26th Thomas Lowe Gray lecture, presented by Dr. T. W. F. Brown, research director of Pametrada, at a meeting of the Institution of Mechanical Engineers on January 15. Although the survey dealt primarily with marine turbines, a number of land installations recently designed were mentioned, to enable comparisons to be drawn between the two fields of application. From the author's statements it appeared that the trend was towards turbines using steam at 1,500 deg. F. with up to two stages of reheat, and cooled gas turbines operating at temperatures of 3,500 deg. F. The cost of special materials required to achieve these figures would be high but they amounted to less than 2 per cent. of the " steam up " weight, while the fuel used during the ship's lifetime was 25,000 per cent. of this weight.

### MARINE STEAM TURBINES

In Great Britain to-day, the usual steam conditions for propulsion turbines for merchant ships having power outputs in the region of 10,000 shaft horse-power, at present under construction, were 600-650 lb. per square inch gauge and 850 deg. F. total temperature, measured at the outlet from the superheaters. The highest steam conditions in use in British ships were those in three Alfred Holt vessels, where boiler pressures of 625 lb. per square inch and total temperatures of 950 deg. F. were employed. The turbine machinery for these vessels had been made by the Metropolitan-Vickers Electrical Company, Limited, and the maximum horse-power per set was 8,000 shaft horse-power. In service the specific fuel consumption was 0·54 lb. per shaft horse-power per hour for all purposes. Dr. Brown said that the company were to be congratulated on the fuel-consumption figure in view of the ship's considerable " hotel " load.

Three sets of machinery to Pametrada design were now being built and these would have steam conditions at the superheater outlet of 600 lb. per square inch and 950 deg. F. Two of the sets would develop 7,500 shaft horse-power and the third 12,500 shaft horse-power. The high-pressure casing was of the double-casing design. By virtue of the construction adopted, the outer casing, containing exhaust steam at 25 lb. per square inch gauge and at a temperature of 400 deg. F. corresponding to an inlet temperature of 950 deg. F., would provide the main strength girder for the high-pressure ahead and astern turbines.

In the United States, as far as was known, the highest-temperature installations, in merchant ships, were operating at 1,020 deg. F. total temperature and 650 lb. per square inch gauge, at the boiler outlet, the turbine sets each developing 16,500 to 18,000 shaft horse-power. These turbines, which had been working satisfactorily for some time, had an all-purpose specific fuel consumption during a 24-hour period in ballast of 0·498 lb. per shaft horse-power per hour at 16,031 shaft horse-power. The vacuum during this period was 27·9 in. Hg. instead of 28·5 in., at which the consumption would have been 0·489 lb. per shaft horse-power per hour. Soon to come into service in the U.S.A. were the " Mariner " class vessels, which would have single-screw machinery, a normal shaft horse-power of 17,500 and a maximum rated shaft horse-power of 19,250. The condition at the superheater outlet was expected to be 600 lb. per square inch and 865 deg. F.

Steam conditions of 780 lb. per square inch and 869 deg. F. were given as the highest figures used by the Compagnie Electro-Mécanique in France. These were for the Ville de Tunis, which had a power of 13,000 s.h.p. on two shafts.

The Germans, prior to 1939, had made use of temperatures up to 860 deg. F. Their warship Gueisenau (1935), a twin-screw vessel, had 13,000 shaft horse-power per shaft, and steam conditions of 735 lb. per square inch and 842 deg. F. total temperature, but the fuel rate, which was 0·638 lb. per shaft horse-power per hour, was poor. The highest temperature employed in their new vessels was reported as 840 deg. F., with provision for operating at 930 deg. F. for short periods.

### LAND INSTALLATIONS

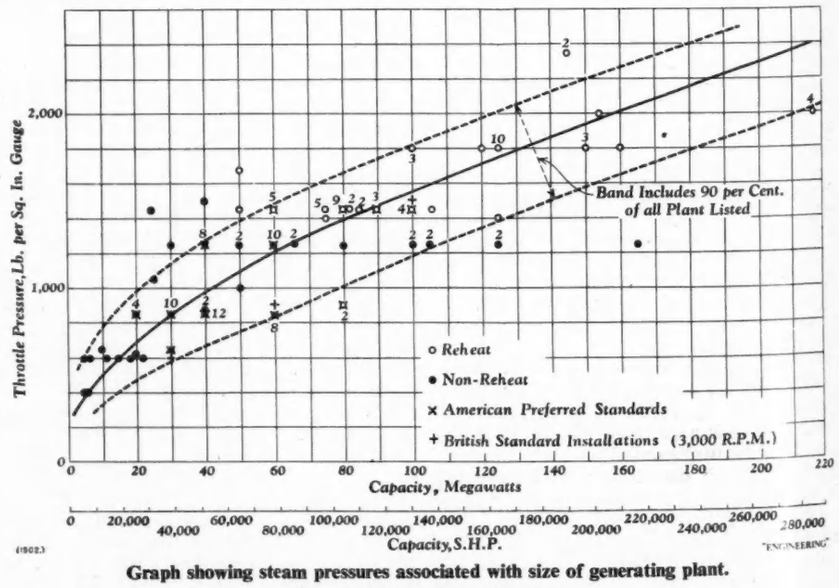
Steam turbines for use on land were, owing to their more favourable operating conditions, better able to use higher temperatures than those employed at sea. These conditions were: running at constant speed, and no reversal or manœuvring requirements, which, apart from pressure, allowed temperatures to be greater than those in marine service. In general these sets were many times larger than any built for marine purposes, 60,000 shaft horse-power per shaft still being the upper limit for marine installations. For power generation, units of 217 MW had been constructed which were equivalent to about 290,000 shaft horse-power. The diagram on this page shows the steam pressures associated with different sizes of generating plant in use in Britain and U.S.A. The points on the diagram apply to 143 units. It would be seen that lines defining the upper and lower pressure limits in relation to size had been drawn on the diagram to include 90 per cent. of all units shown. In the portion of the curve covering steam turbines for merchant ships, where from 4,000 to 20,000 shaft horse-power was used, the corresponding pressures were 260 to 630 lb. per square inch. It was clear that in relation to size the marine industry employed higher pressures than those applicable to land installations of equivalent power output.

In 1931, the British Thomson-Houston Company installed at Detroit a 10-MW machine which operated at 1,000 deg. F. They were now constructing the Meaford machine which was to operate at 1,050 deg. F. This was a 3,000-r.p.m. two-cylinder tandem double-flow machine of 60 MW output, in which a pressure of 1,500 lb. per square inch would be employed with six stages of feed heating. Among other British companies, C. A. Parsons and Company, Limited, had in production 125-MW machines to operate at 1,000 deg. F. total temperature, with reheat, and 1,500 lb. per square inch. The English Electric Company, Limited, were producing a 60-MW turbine, with an operating temperature of 1,050 deg. F. and a heat rate of 8,788 B.Th.U. per kWh, employing a simple form of double casing in the high-pressure turbine with a single Curtis wheel followed by single-row impulse stages. This would be the first set to operate at such a temperature in Britain. Designs for turbines of 1,050 deg. F. and 1,500 lb. per square inch were being developed by Fraser and Chalmers. In 1935, the Metropolitan-Vickers Electrical Company, who had a long record of building high-temperature turbines, installed in Moscow a 24-MW back-pressure turbine operating at 1,763 lb. per square inch and 933 deg. F. total temperature. In 1937, they produced a 100-MW set using 950 deg. F. for Battersea " B," and since the war they had worked on a 100-MW, 1,050 deg. F. set for Castle Donnington. A design for a 120-MW set with a pressure of 1,500 lb. per square inch, 1,000 deg. F., with reheat to 1,000 deg. F. had also been developed.

In the United States the General Electric Company had received an order for a 125-MW set to operate at 4,500 lb. per square inch, and 1,150 deg. F., reheated to 1,050 deg. F. and again to 1,000 deg. F. The overall thermal efficiency of this machine was expected to be more than 40 per cent. It was known to have the highest inlet temperature of any turbine designed for operational use at the present time. The Westinghouse Electric Corporation had in operation a 125-MW machine operating at 1,500 lb. per square inch gauge, 1,050 deg. F. total temperature reheated to 1,000 deg. F., with a back pressure of 1·5 in. Hh. absolute. They also had an order for a 185-MW set to use steam at 2,350 lb. per square inch gauge.

Dr. Brown mentioned, in connection with American development, correspondence that he had received from Mr. R. C. Allen of the Allis Chalmers Manufacturing Company, which stated that American engineers were reluctant to advance rapidly with designs for operation in the high-temperature range – above about 1,000 deg. F. – where ferritic materials could not be used because of their reduced strength. Austenitic steel was still under extensive study to determine how it might be applied to the higher-temperature plants.

On the Continent, France and Switzerland were both building similar designs of machines. The former had under construction sets of 125 MW to operate at pressures of 1,500 and 1,800 lb. per square inch and 1,000 deg. F., and in the


Throttle Pressure, Lb. per Sq. In. Gauge
2,000
1,000
0
Band Includes 90 per Cent. of all Plant Listed
o Reheat
• Non-Reheat
× American Preferred Standards
+ British Standard Installations (3,000 R.P.M.)
0 20 40 60 80 100 120 140 160 180 200 220
Capacity, Megawatts
0 20,000 40,000 60,000 80,000 100,000 120,000 140,000 160,000 180,000 200,000 220,000 240,000 260,000 280,000
Capacity, S.H.P.
(1902)
"ENGINEERING"

**Graph showing steam pressures associated with size of generating plant.**

All speeds 3,600 r.p.m. for American plants.

The numbers on the graph refer to the numbers of installations for the conditions indicated by the points.

latter a number of high-pressure sets were being built. One of these was a 150-MW unit to operate at 1,550 lb. per square inch and 977 deg. F. In Germany a small 11·4 MW machine had been constructed for 2,270 lb. per square inch at a total temperature of 1,130 deg. F., which worked against a back pressure of 425 lb. per square inch.

One of the important aspects to be considered in the use of high-temperature steam was that of reheating. There were three methods that could be used : steam reheat, gas reheat and liquid-metal reheat. The latter was based upon recent developments in the use of liquid metals (such as sodium and sodium-potassium alloy) as heat-transfer fluids in the development of nuclear-power plants. The liquid metal would be used to transfer heat from the heater section to a heat exchanger adjacent to the turbine. Circulation of the liquid required little power even at inlet conditions of 600 lb. per square inch and 950 deg. F. Pipes smaller than those carrying steam could be used and the gain due to this method of reheating, it was expected, would be about 8 per cent., which might well justify the increased cost.

### MARINE GAS TURBINES

The gas turbine for marine use had been covered by many summaries and the speaker said that he did not propose to present another; the best of these was the " Gas Turbine Progress Report – 1952 " (*Trans. A.S.M.E.*, vol. 75, page 121, 1953). The Pametrada gas turbine developing 3,500 shaft horse-power, designed in 1946, had been operating since 1948 and had proved invaluable in examining the many problems associated with this field of work. This unit had the lowest specific fuel consumption known to the speaker, and if the efficiency of the low-pressure compressor was corrected it would be better than a steam turbine of the same output using steam at 1,000 deg. F. The present figure was 0·488 lb. per shaft horse-power per hour.

In designing a high-temperature cooled gas turbine the first consideration was the gas temperature which the combustion chamber could withstand. In theory, a combustion temperature rise of 4,000 deg. F. was possible but the maximum obtainable in practice depended on the quality of the refractory for lining the chamber. The limit with present materials was 3,500 deg .F. Carbon and Zircon were among those that came near to this figure. Effective cooling of the metal parts would be necessary to enable a life of 100,000 hours to be obtained.

The best fuel consumption that could be seen within the scope of his survey of the hot gas turbine was 0·33 lb. per shaft horse-power per hour for all propulsive purposes.

### CONCLUSIONS

Higher efficiency was guided by the laws of thermodynamics, of which the Second Law led to the expression $(T_1 - T_2)/T_1$ as the maximum efficiency theoretically attainable between the upper and lower temperature limits measured on the absolute scale. The effect of $T_1$ had been examined, in the lecture, as far beyond present practice as possible and within the scope of known materials. It had been shown that for marine use steam turbines had a long way to go. It was also clear that the high-temperature gas turbine would be lighter, possessing higher thermal efficiences than were possible in steam plant.

# AMPLIDEX SYSTEM FOR CONTROLLING ALTERNATORS

## AMPLIFYING EXCITATION UNIT FOR SELF-REGULATING MACHINES

The Brush Electrical Engineering Company, Limited, Loughborough, have developed a system of control – known as the Amplidex – which is intended for use with the self-regulating alternators described on page 733 of our 175th volume (1953). These alternators, it may be recalled, are made for outputs up to 150 kW. The system can also, however, be applied to standard alternators of salient-pole construction with large air-gaps and normal proportions of field and armature ampere-turns with which an ordinary automatic voltage regulator would usually be employed. It has the same capacity for dealing with leading power factor loads.

### DETAILS OF CONTROL SYSTEM

The principal features of the Amplidex control system are shown diagrammatically in Fig. 1. The alternator voltage is supplied through an isolating transformer *a* to two bridge rectifiers *b* and $b_1$, one of which is shunted by the saturated reactor *c* and the other by the series capacitor *d*. The outputs from these rectifiers are supplied to two resistances *e* and *f* which are connected in series and the difference voltage across these resistances supplies the error signal to a sub-exciter. This sub-exciter is mounted in tandem on a single frame with the main exciter, the latter supplying the alternator excitation.

The saturated reactor *c* maintains the voltage across one rectifier constant, while the voltage of the other varies in direct proportion to the alternator voltage. When the two voltages are equal no current is therefore supplied to the exciter field. If, however, the alternator voltage varies, an error signal is transmitted the strength and direction of which vary the exciter field current, thereby rapidly correcting it to its set value. Both the reference voltage provided by the saturated reactor and the current in the capacitor *d* are sensitive to the frequency, but as these two effects cancel out no variation occurs due to a change in frequency.

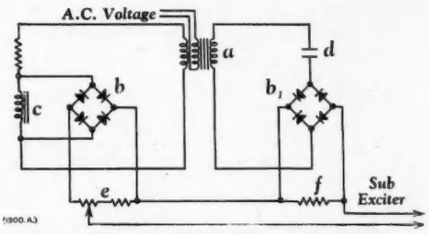



**Fig. 1 Diagram of Amplidex control system.**

### HIGH AMPLIFICATION NECESSARY

For the alternator to be controlled by the small output of the detector circuit it is necessary to use a high value of amplification and a rapid rate of response. The main and sub-exciters are therefore connected in cascade. The field system of the main exciter is laminated and compensated, the laminations being similar to those used on induction-motor stators. Certain teeth are, however, removed to form commutating zones. The stator is wound with concentrated excitation windings and a fully distributed compensating winding. The sub-exciter is a simple separately-excited machine, but also has a laminated field.

A compensating winding is necessary to enable the exciter to operate with comparatively high armature loading and low magnetising power, a combination which results in high amplification and quick response. It also ensures that commutation is good during the " field forcing ", which is necessary to restore the alternator voltage quickly when sudden changes of load occur. A damping circuit is included so that the maximum recovery rate can be maintained without any falling off in stability.

### OPERATING RESULTS

Self-regulating alternators of Brush construction when fitted with Amplidex control give a voltage regulation within $\pm 2\frac{1}{2}$ per cent. from cold to hot at varying power factors and from no load to full load, allowing for the usual 4 per cent. variation in engine speed. As will be seen from Fig. 2, when a full load at 0·8 power factor lagging is thrown off the voltage rise is arrested in less than 0·2 second and the voltage overshoot is within 20 per cent. of the normal voltage. When full load at unity power factor is thrown off very little voltage disturbance occurs, as will be clear from Fig. 3. Similar voltage variations occur when the load is switched on, while within the full rated range of output voltage recovery is obtained for any condition of load change within one second or less.

The Amplidex system will operate over a voltage range of 380 to 440 volts and a frequency range of 50 to 60 cycles. If necessary, a series-parallel stator connection can be provided to give dual voltage without changing the connections to the control circuit. Both voltage ranges are therefore covered by the same rheostat and the full rated output can be obtained at either voltage.

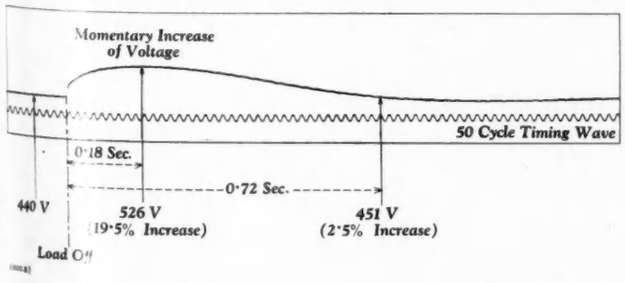



**Fig. 2 Voltage rise on removal of 0·8 power factor lagging load.**

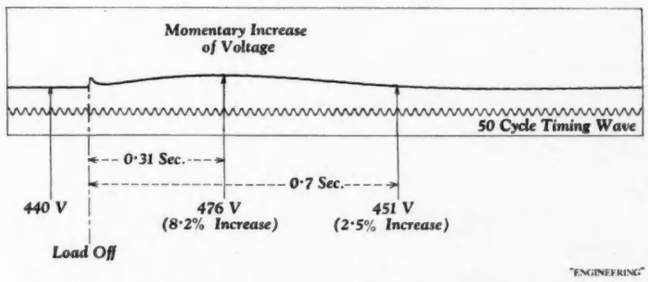



**Fig. 3 Voltage rise on removal of unity power factor load.**

## LAUNCHES AND TRIAL TRIPS

M.S. "BRITISH CORPORAL."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Belfast, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 490 ft. between perpendiculars by 65 ft. by 36 ft.; deadweight capacity, about 14,000 tons. Harland-B. and W. six-cylinder two-stroke single-acting opposed-piston Diesel engine. Launch, December 9.

M.S. "HØEGH SHIELD."—Single-screw oil tanker, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, for Skibs A/S Arcadia, Borre, Norway (Managers: Leif Høegh & Co. A/S, Oslo, Norway). Main dimensions: 526 ft. between perpendiculars by 69 ft. 9 in. by 39 ft. 3 in.; deadweight capacity, 18,150 tons on a draught of about 30 ft. 5 in. B. and W. nine-cylinder two-stroke single-acting Diesel engine, developing 9,000 i.h.p. Speed, 15½ knots. Launch, December 14.

M.S. "NEPTUNE."—Single-screw cargo vessel, built and engined by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne, for the Compañia Naviera Hesperia S.A., Panama City, Panama. Main dimensions: 435 ft. between perpendiculars by 60 ft. by 39 ft. to shelter deck; gross tonnage, 5,750; deadweight capacity, about 10,000 tons on a draught of 26 ft. 5 in. Swan Hunter-Doxford four-cylinder opposed-piston combined stroke oil engine, developing 4,400 b.h.p. at 115 r.p.m. in service. Service speed, 13¾ knots. Trial trip, December 15.

M.S. "BRITISH ENVOY."—Single-screw oil tanker, built and engined by William Doxford and Sons, Ltd., Sunderland, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 515 ft. by 69 ft. 6 in. by 37 ft. 6 in.; deadweight capacity, 16,000 tons on a draught of 30 ft. Doxford six-cylinder opposed-piston oil engine, developing approximately 6,450 b.h.p. at 117 r.p.m., and a speed of about 14 knots. Trial trip, December 17.

S.S. "IRISH ELM."—Single-screw cargo vessel, built and engined by William Gray & Co., Ltd., West Hartlepool, for Irish Shipping, Ltd., Dublin. First of a series of six vessels for these owners. Main dimensions: 410 ft. between perpendiculars by 58 ft. by 37 ft. 8 in. to shelter deck; deadweight capacity, 8,920 tons on a draught of 25 ft. 11¼ in. Triple-expansion steam engine, working in conjunction with a Bauer Wach exhaust turbine, and three oil-fired cylindrical boilers. Service speed, 12½ knots. Trial trip, December 17.

M.S. "DUNDEE."—Single-screw cargo vessel, with accommodation for six passengers, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Dundee, Perth and London Shipping Co., Ltd., Dundee, for service on the St. Lawrence River and Great Lakes, Canada. Main dimensions: 251 ft. between perpendiculars by 43 ft. by 29 ft. 2 in. to shelter deck; deadweight capacity, about 2,950 tons on a draught of 18 ft. 11 in. Nine-cylinder Diesel engine, developing 1,640 b.h.p., constructed by British Polar Engines, Ltd., Glasgow. Speed, 11 knots. Launch, December 18.

S.S. "NORVEST."—Single-screw oil tanker, built and engined by Smith's Dock Co., Ltd., South Bank-on-Tees, for the Bergen Kulkompani A/S, Bergen, Norway. Main dimensions: 315 ft. between perpendiculars by 47 ft. 6 in. by 21 ft. 3 in. to harbour deck; deadweight capacity, 4,000 tons on a draught of about 19 ft. 6 in. Fredriksstad steam engine, developing 1,600 i.h.p. and a speed of 11¼ knots in service. Launch, December 19.

S.S. "MELIKA."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for the Afran Transport Co., Monrovia, Liberia (a subsidiary of the Gulf Oil Corporation, New York). Sixth vessel built for these owners. Main dimensions: 630 ft. between perpendiculars by 87 ft. by 45 ft. 6in.; deadweight capacity, 32,000 tons on a summer draught of 34 ft. 2 in. Double-reduction geared turbines, developing a maximum of 13,750 s.h.p. at 108 r.p.m., constructed by Richardsons, Westgarth & Co., Ltd., Wallsend-on-Tyne. Steam supplied by two Foster Wheeler oil-burning boilers. Speed, 15½ knots. Launch, December 19.

M.S. "LAURELWOOD."—Single-screw oil tanker, built by Sir James Laing and Sons, Ltd., Sunderland, for John I. Jacobs & Co., Ltd., London, E.C.3. Main dimensions: 512 ft. between perpendiculars by 72 ft. 6 in. by 41 ft. 2 in.; deadweight capacity, 18,560 tons on a summer draught of 30 ft. 8 in. N.E.M.-Doxford six-cylinder opposed-piston heavy-oil engine, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, 14¾ knots. Trial trip, December 19.

# OILY-WATER SEPARATOR

## CONTROL BY ELECTROSTATIC PROPERTIES OF THE LIQUIDS

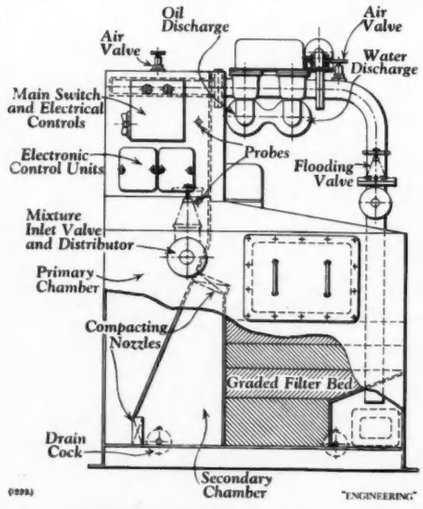
To meet the requirements of the Oil in Navigable Waters Act, it has become encumbent on shipowners to provide efficient separators to deal with oily bilge and ballast-water discharge. Elsewhere, industry as a whole is generally required by the local by-laws to separate all oil from discharge before the latter is put into the drainage system of the local authority. Among the separators now available for this work are those made by White's Marine Engineering Company, Limited, Hebburn-on-Tyne; these separators are being made in twelve sizes having capacity ratings of between 5 and 100 tons per hour.

The separators are quite self-contained and no additional tanks or filters are required, a large filter being incorporated for removing the final traces of emulsified oil which remain in the water after the initial separation. It is entirely closed and has been designed to withstand considerable pressure so that it may be installed in any suitable position on a vessel, either above or below the water-line as may be required. Since there are no free oil or water surfaces, the operation of the separator is not affected by either list or change of trim of the vessel.

### PRINCIPLE OF SEPARATION

The oil and water mixture to be separated is pumped directly through the inlet valve to enter the primary separation chamber through vertical apertures in the distributor. Between 90 and 95 per cent. of the oil in the mixture is separated in the primary chamber, the oil rising and collecting in the upper section. The remainder of the mixture passes down through the primary chamber and, because of the convergence of the passage, the oil is compacted into larger droplets and progressive separation commences.

The mixture then passes into the secondary chamber via compacting nozzles, where the process is repeated, the mixture rising to pass through another set of nozzles before entering yet a third chamber containing the filter bed. As the flow of the mixture changes direction to enter the filter bed, the small amount of compacted oil remaining is released and rises through passages into the top section of the primary chamber. The filter consists of a well-graded material through which the discharge water is finally passed and the remaining traces of contamination, in the form of finely divided oil or oil-coated grit, are removed.




**This oily-water separator uses changes in the capacitance of the separator and its contents for operating the discharge valves.**

The separated oil is drawn off intermittently from the top of the apparatus, and in the case of fuel oil is led back to the bunker tank for burning.

### ELECTRONIC CONTROLS

The control of the discharge may be achieved either electronically, as in the standard models, or manually.

In the standard model, which is the type shown in the accompanying drawing, electric motors are used to operate the valves which discharge the separated oil and water when the chambers are full. The electronic method of control employed is completely independent of the specific gravities of the liquids involved and no adjustments are therefore required if the specific gravity of the oil changes.

For this type of control the electrostatic properties of the liquids are utilised. This is achieved by inserting two metal probes into the oil chamber at the desired upper and lower water levels, and applying a voltage of radio frequency to each. Each probe, the liquid surrounding it, and the tank of the separator, together act as an electrical condenser. Because different liquids have different dielectric properties, the capacitance of this condenser changes with the change of liquid surrounding the probe.

Any change of capacitance causes a relay to operate, which in turn operates the contactors controlling the discharge valves. For example, when the oil level reaches the lower probe, the relay operates and the oil discharge valve is opened, thus discharging oil from the separator until such time as the water level reaches the upper probe. When this occurs, another relay operates and actuates the water-discharge valve, thus discharging water from the separator until the oil level again reaches the lower probe. The oil and water valves are electrically and mechanically interlocked to prevent both oil and water being discharged simultaneously.

Because of the low voltages and powers applied to the probes, there is no danger of spark or fire hazard with the oil in the separator.

As alternatives to electrical operation of the valves, it is possible to use either compressed air or steam to actuate the valves. In these cases, control may be effected either electronically or by means of a float mechanism as required.

### MANUAL CONTROL

These separators are also available with manual controls, which have been reduced to a minimum, comprising two test cocks discharging into a funnel and a single lever for operating oil and water discharge valves. The method of operation is straightforward.

In view of the small number of moving parts, and apart from periodic inspection, little attention need be given to these separators. For the models controlled electronically the equipment contains two valves of a standard type such as are used in radio sets, and replacements are therefore easily obtained. Several thousand hours of service can be reasonably expected before replacement of the valves becomes necessary.

Tests made by an independent analyst showed that with an oil and water mixture of up to 75 per cent. oil, the oil content of the discharged water was 1·7 parts per million of water.

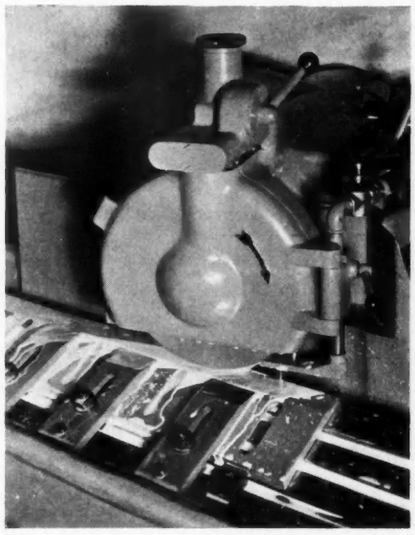
# GRINDING LONG KNIVES

## MACHINE WITH OSCILLATING WHEEL-HEAD

The machine illustrated herewith has been designed and constructed by Müller A.G., Brugg, Switzerland, a subsidiary of George Fischer, Limited, Schaffhausen, for grinding the long heavy knives used in planing and other woodworking machines, guillotines, etc., and also in the paper industry. It is made in a range of six sizes for grinding knives with maximum lengths from 1,700 mm. to 5,000 mm. (say, 5 ft. 6 in. to 16 ft. 4 in.). The bed, which is supported on two pedestals in the smaller sizes and on three in the larger sizes, is trough-shaped at the top, forming a reservoir for the coolant fluid which drains from it into a long trough at the back of the machine. Within the trough at the top of the bed is a long narrow slotted table to which the knife to be ground is clamped. The table can be tilted to any angle, to suit the bevel of the knife, the angle being adjusted by worm gearing operated by the handwheel on the right of the illustration.

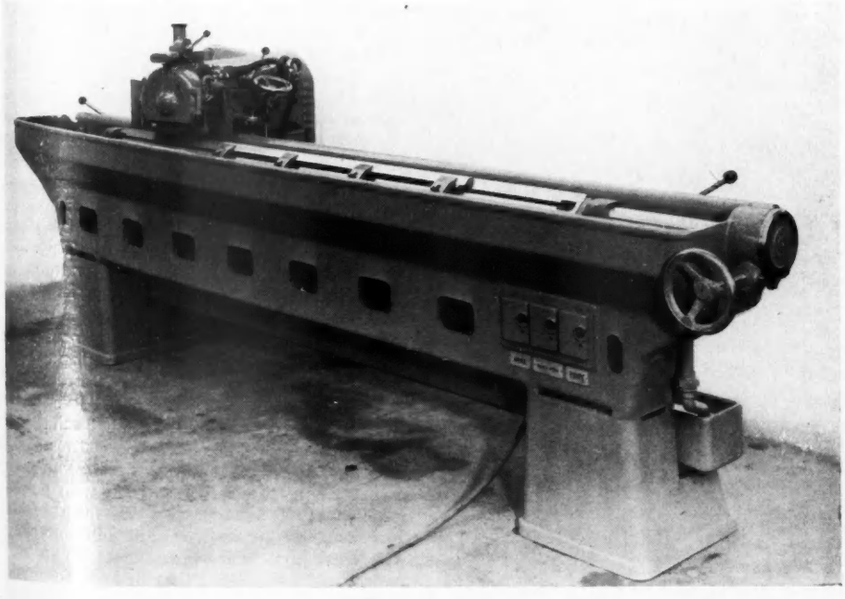
The grinding head is mounted on a travelling carriage at the back of the machine, the carriage moving successively in both directions and being reversed automatically at each end of its travel to suit the length of the knife being ground. Separate motors for driving the grinding wheel, traversing the carriage, pumping the coolant and for oscillating the grinding head, for a purpose which will be explained later, are all accommodated in the travelling carriage. The coolant is drawn from a long trough the end of which can be distinguished on the right of the illustration below.

It will be obvious that the rapid removal of the heat evolved in grinding is essential if the physical properties of the steel near the cutting edge are not to be adversely affected and the production of hair cracks is to be avoided. For this purpose a large volume of coolant is delivered at the periphery of the grinding wheel just before it makes contact with the work. To enhance the cooling effect the grinding head is given an oscillating motion in the horizontal plane as it is traversed over the work. As a result, a sinuous area, which crosses and recrosses the cutting edge of the knife, is ground along the bevel. In a single traverse parts of the cutting edge are therefore missed, but these parts are ground when the grinding head is travelling in the opposite direction. As the thickness of the grinding wheel is greater than the width of the bevel, the whole area of the latter is ground in a double traverse of the grinding head.



**The grinding wheel of this machine produces a good finish on long knives, straight-edges, etc., because it is given a sinuous motion along the workpiece. The motion also assists cooling.**

The feed of the grinding wheel into the work is automatic and is adjustable from 0·002 mm. to 0·01 mm. per traverse. This small feed, in conjunction with the cooling arrangements described, are claimed to ensure an exceptionally keen and durable cutting edge. The machine can also be used for finish grinding the working faces of straight-edges and other long bars.



**The wheel on the right is used for adjusting the grinding angle of the workpiece.**

# VERY HIGH FREQUENCIES FOR SOUND RADIO

## *Frequency Modulation Recommended*

The second report of the Television Advisory Committee, which was appointed to advise the Postmaster-General on the development of television and sound broadcasting at frequencies above 30 megacycles per second, was published on Monday, January 18. It complies with a request, made after the first report was completed last May, that early attention should be given to the best methods of introducing higher frequency sound broadcasting, to the form of modulation that should be used and to the problems which would be involved in making a change over to any new system. As a result, a technical sub-committee was set up to examine the relative merits of amplitude and frequency modulation and have unanimously recommended the adoption of the latter. This recommendation has been approved by the full committee, with the exception of Mr. C. O. Stanley, who submitted a minority report.

In the course of their report the technical sub-committee point out that to provide three very high-frequency programmes would cost £3·5 millions for transmitter installations if frequency modulation were used and £9 million if amplitude modulation were employed, the annual charges being £800,000 in the first case and £2 million in the second. This large difference is due to the fact that 36 amplitude-modulation stations would be required as against 25 for frequency modulation and that the installed capacity would be 2,800 kW and 760 kW respectively in the two cases.

As regards the design of very high-frequency receivers and adaptors for existing sets, it is considered that the demand for adaptors would be exceeded by the demand for new sets. It is estimated that the additional cost of incorporating very high frequencies in new receivers would be about 30 per cent., although this would be offset to some extent if the short-wave band were omitted. With frequency modulation it would be possible to broadcast three programmes with a national coverage in the 88 to 95 megacycle band, but it would be difficult to do this with amplitude modulation. The problem of interference due to receiver oscillation radiation is likely to be more troublesome with receivers for narrow band amplitude modulation than with frequency modulation receivers.

The conclusion is therefore reached that the amplitude modulation wide-band system has specific disadvantages and no advantages relative to the frequency modulation system. For the amplitude modulation narrow-band system the only advantage is a possible saving in the frequency spectrum required. Although this is of great importance, its realisation in practice would be beset with many difficulties. The recommendation that frequency modulation should be adopted does not, however, necessarily hold good if very high-frequency sound broadcasting is restricted to a small number of stations.

### MINORITY REPORT

In his minority report Mr. C. O. Stanley points out that the adoption of frequency modulation will mean a radical change from the standards employed in all other sound broadcasting in this country. It is a step which, if taken at all, should only be taken when the whole future pattern of television and sound broadcasting is much clearer than it is at the moment.

# ORIGINS OF MECHANICAL SERVO-MECHANISMS

The growth in the use of mechanical servo-mechanisms has been one of the more notable consequences of war-time scientific developments, but the principles were recognised and applied many years before even the first world war, particularly in connection with the steering of ships and torpedoes. If, however, this type of mechanism be considered to include automatic regulators of various kinds, their true origins must be sought even farther back in engineering history, as was shown in the excellent paper that was presented by Mr. H. G. Conway, M.A., M.I.Mech.E., F.R.Ae.S., at a meeting of the Newcomen Society held in the Iron and Steel Institute, London, S.W.1, on January 13.

One of its earliest forms was the centrifugal steam-engine governor invented by James Watt in 1784, and even that could be shown to have predecessors, if not progenitors, in the regulation of windmills. The term "servo-motor," however, as Mr. Conway pointed out, "was undoubtedly invented by Joseph Farcot about 1870. In his book, *Le Servo-Moteur ou Moteur Asservi*, published in Paris in 1873, he defined its principle as putting "any motor or engine under the absolute control of an operator by the movement of his hand directly or indirectly on the control member of the motor, so that the two go, stop, go back and forward together, the motor following step by step the finger of the operator, imitating as a slave every movement." This would appear to be also the origin of the term "slave" as applied to the repeating motor, and describes what would now be termed a "closed-loop positional servo."

The first application to ships' steering gears, so often attributed to J. McFarlane Gray, designer of the steam steering-gear of the Great Eastern, and patented in Great Britain in 1866, appears to have been due, however, to F. E. Sichels of New York, who took out patents in the United States in 1853 and 1860, but, according to Mr. Conway, may have been working on the invention as early as 1849. Farcot stated in his book that his servo-motors had been applied to the gun turrets, as well as the rudders, of four French gunboats by the year 1872, but, apparently, nearly 60 years elapsed before a similar control was adopted on guns in the British Navy, though the Royal Navy was one of the first to use servos on torpedoes. The hydraulic type, for steering gears, was invented in 1870 by Andrew Betts Brown, then of Birkenhead, and subsequently one of the founders of Brown Brothers, Limited, Rosebank Ironworks, Edinburgh. "The theoretical analysis of servo devices," said Mr. Conway, "may be said to have started with a notable contribution by J. Clerk-Maxwell in the *Proceedings* of the Royal Society, March 5, 1868, 'On Governors'."

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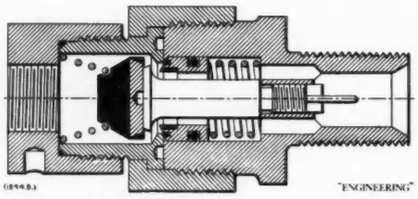
## TRENCHING ATTACHMENT FOR TRACTOR

It is always an advantage when a machine can do more than one job and a fresh field of operation has been made available to the Allis-Chalmers H.D.5G Tracto-Shovel by the addition of a trench-hoe attachment.

This hoe is interchangeable with the standard Tracto-Shovel digging bucket and the change is a simple one, involving only six pins. The hoe is of tubular construction and is designed to give the same balance as the standard bucket.

Having a capacity of ⅛ cub. yd., this hoe will excavate a trench 27 in. wide and up to 8 ft. deep. The reach from the radiator guard is 11 ft. and this is also the dumping clearance. Material can be dumped at either side by slewing the tractor.

These attachments are imported by Mackay Industrial Equipment, Limited, Faggs-road, Feltham, Middlesex, who are the agents for Allis-Chalmers tractors in this country.



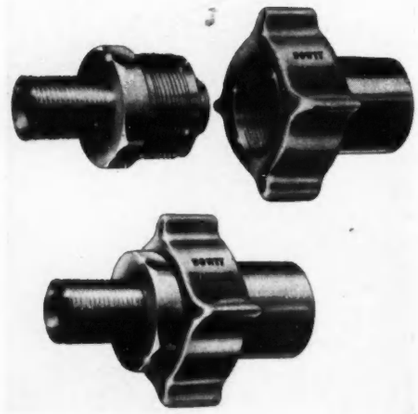

**When this high-pressure pipe coupling is disconnected each section of pipe is automatically sealed by a spring-loaded valve.**

## SELF-SEALING PIPE COUPLING

For joining pipelines carrying fluids under pressures of up to 3,000 lb. per square inch, Dowty Auto Units, Limited, Ashchurch, near Tewkesbury, Gloucestershire, have developed a leak-proof self-sealing pipe connection which is easily coupled or uncoupled by hand, without loss of fluid or risk of an airlock. A comprehensive range of sizes is available, and separate half-couplings can be supplied. The example shown below, the Tractaline coupling, is recommended for coupling the pressure lines of agricultural tractors to hydraulically-operated farm implements.

As shown in the accompanying diagram, the female half of the coupling incorporates a spring-loaded conical valve, the bonded rubber of which, when the pipes are disconnected, makes a seal against the inner face of the body core. The male half of the coupling embodies a spring-loaded piston with two bonded rubber rings, and a mushroom-headed valve. When disconnected, the inner piston ring is pressed against the underside of the piston valve, forming a seal.

When the pipes are connected, the faces of the two valves are pressed together, and the conical valve opens. At the same time, a shoulder of the core in the female part makes a seal against the outer bonded rubber ring of the piston, which is depressed to allow free fluid flow.



**Dowty self-sealing pipe coupling for agricultural applications.**

## VIBRATING FORK USED TO MEASURE RATE-OF-TURN

### *Proportional Signal Generated*

Under development in America by the Sperry Gyroscope Company, Division of the Sperry Corporation, Great Neck, Long Island, New York, is a new form of instrument for measuring rate-of-turn, employing a vibrating fork in place of the gyroscopic rotor currently used in such instruments. The principle of operation of the Sperry Gyrotron angular tachometer depends upon the fact that, if a vibrating fork is rotated about its axis, the oscillating masses of the fork produce an oscillating torque about the fork axis.

In the sensing unit of the experimental instrument, the fork is vibrated at its natural frequency by electromagnetic coils. The oscillating torque generated during a turn causes a torsion vane at the heel of the fork to oscillate between two magnetic pick-up coils. The amplitude of the signal thus generated gives a measure of the angular velocity of the turn, and its phase, relative to that of the fork vibration, indicates the direction of the turn.

The Sperry company cite the following advantages for the instrument. It is inherently rugged and insensitive to shock. Since there are few moving parts and no bearings, it should have a long life and little servicing is required. It is sensitive only to angular velocity about a single input axis, and is free from errors arising from negative acceleration. Angular rate measurements over a range of a million to one can be obtained, with good linearity, and a response of the order of 0·005 sec. can be achieved.

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## PRESTRESSED CONCRETE BEAMS WITH HIGH TENSILE STRESSES

What is believed to have been the first structure of its kind in the United Kingdom, a framed structure in which high tensile stresses have been allowed in the concrete of the principal prestressed concrete beams, has recently been brought into commission by the Eastern Region of British Railways. The beams were made on the ground, post-tensioned and then hoisted into place by a mobile crane. Under the worst conditions an allowance has been made for the exceptionally high concrete stress of 650 lb. per sq. in. in tension.

The beams are the principal members of the roof for a new goods shed at Bury St. Edmunds. It has a clear floor space of 200 ft. by 78 ft. and a roof beam clearance of 25 ft. This high working clearance will allow container traffic to be handled by a mobile crane working inside the shed.

Structurally, the shed consists of a nearly flat roof (4 deg. slope) of asbestos sheeting carried on a system of prestressed-concrete beams and purlins, the latter prestressed on the "long-line" system. The columns are of plain reinforced concrete arranged at about 40 ft. centres along the sides of the shed. Beams of 40 ft. span extend along the line of the walls with the 13 principal beams of 78 ft. span across the shed at 20 ft. centres. It is worthy of note that no bolts were used at the bearing points of any of the beams, all of which are held in place solely by their own dead weight and that of the structure that they support.

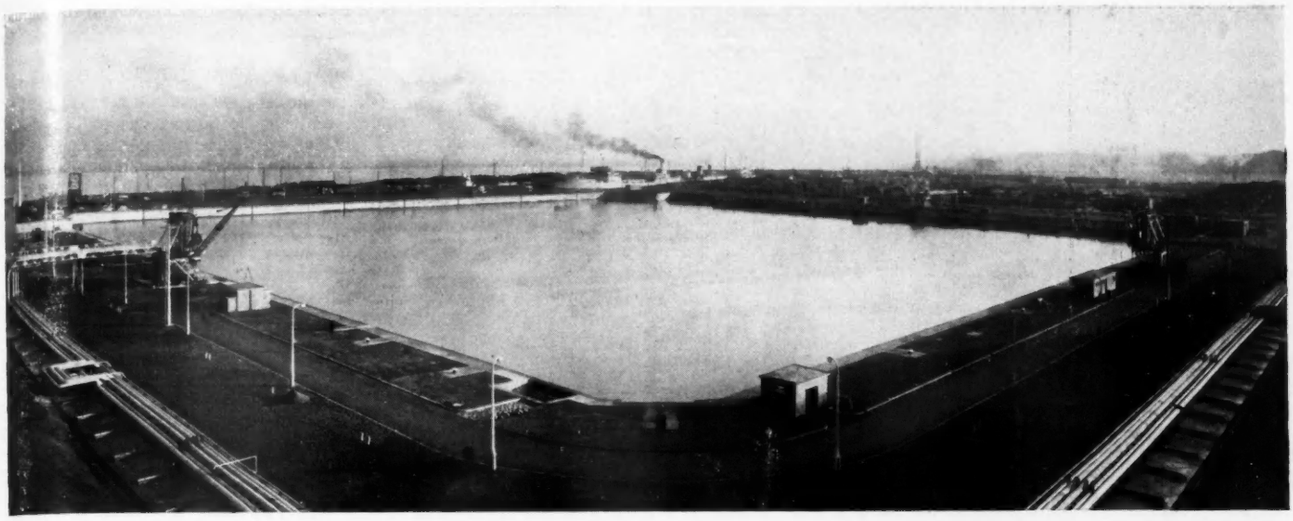

Fig. 1 This view of the largest oil dock in Great Britain shows the entrance lock (on the left), which is controlled by three all-welded sliding caissons. The lock is on the estuary of the River Mersey, adjacent to the western end of the Manchester Ship Canal, which the two ships in the background are entering and leaving.

# QUEEN ELIZABETH II DOCK

## DISCHARGING LARGE OIL TANKERS BY THE MANCHESTER SHIP CANAL

The Queen Elizabeth II Dock, the largest single oil dock in Britain, is designed exclusively for the use of the largest class of tankers bringing crude petroleum to this country for processing at the nearby installations of various oil companies. Some general information on the dock is given in Weekly Survey in this issue.

Fig. 1 is a general view of the dock taken from high ground and looking in an easterly direction. The dock is square in plan and the area of the basin is 20 acres. One side is parallel to the Manchester Ship Canal, the entrance locks of which lie immediately behind the dock-side area on the far side. To the left, on the far side, may be seen part of the basin of the entrance lock, which connects directly with the estuary of the Mersey and is quite separate from the entrance locks to the canal. To the right, on the far side, may be seen the abutments of a link channel not yet constructed and closed off with steel sheet piling. This link channel, when constructed, will permit the entrance locks to the canal to be by-passed and closed off for repair or re-modelling should such work ever become necessary, while canal shipping passes through the basin and out by way of the new lock.

The main contractors for the excavation and concreting were Sir Alfred McAlpine and Son, Limited. Work at the site commenced in 1949 and the permanent engineering staff of the ship canal company were responsible for the design of the new dock and its entrance lock; also for the numerous subsidiary buildings, winch-houses and special oil-handling facilities.

### PRINCIPAL FEATURES

The dock is square in plan with sides 900 ft. in length, which provide four berths of effective lengths of 800 ft., 725 ft., 900 ft. and 730 ft., thus enabling four tankers in the 30,000-ton category to discharge their cargoes at the same time. The entrance lock is 100 ft. in width with an effective total length of 807 ft., divided into two chambers of 177 ft. and 607 ft. effective length, suitable for passing small, medium, or large vessels with the minimum consumption of water.

The entrance lock is divided by three sliding caissons, which makes the Queen Elizabeth II Dock the first wet dock in Britain to employ this means of opening and closing the entrance-lock chambers.

A feature of the basin is the provision of overflow weirs in the four corners for drawing off oil floating on the surface of the water. These weirs have rising sills which, when lowered, permit the surface oil and water to pass over them into settling tanks in which the oil is accumulated and subsequently recovered and passed into the pipelines.

The various oil discharging points are equipped with pipe-line gantries and cranes which are located as shown in Fig. 1. They are designed not only to handle the connecting hoses but also to carry the discharging pipelines overhead so that dock-side traffic is not obstructed. These discharging points connect to ring mains which terminate at a tank-farm, approximately half-a-mile away to the south-east. This tank-farm connects through two 16-in. diameter pipelines, which pass under the canal, to a 20-in. main to Stanlow, from where 27 pipelines re-cross under the canal to the numerous installations of the various oil companies, including the new Shell refinery opposite Stanlow.

The dock operates at the same water level as the canal. Two 5-ft. concrete balancing pipes connect the dock with the canal, passing under

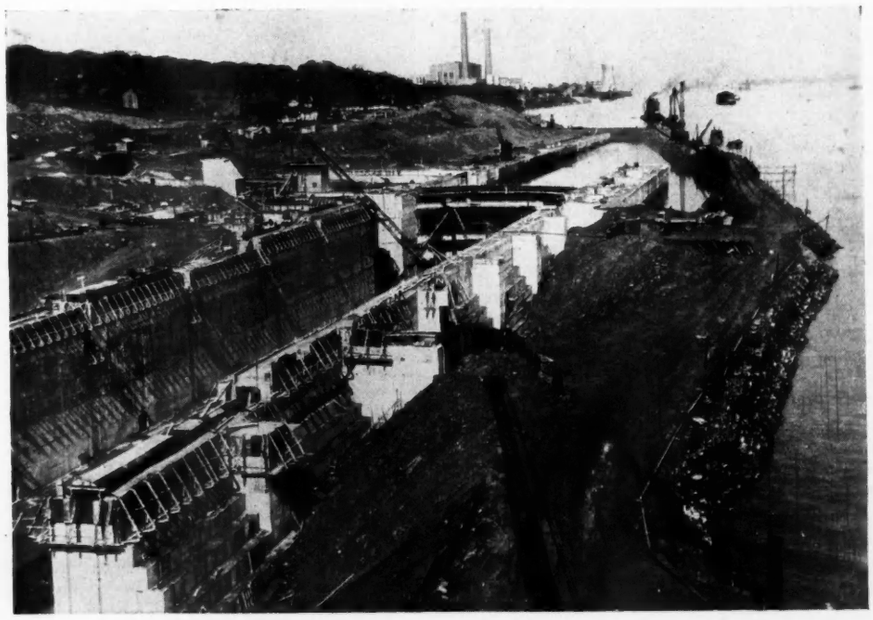

Fig. 2 Climbing shuttering was used for constructing the walls of the entrance lock, as well as for the main dock walls.

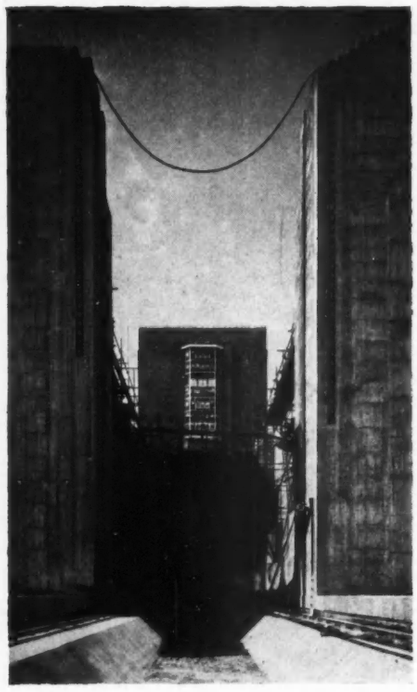

**Fig. 3 Recess for one of the three sliding caissons in the entrance lock. The winch drive for moving the caissons incorporates hydraulic transmission. The winch house is shown in the background.**

berth No. 1 immediately adjacent to and parallel with the canal. The maximum tidal range in the Mersey is 33 ft. and movement through the lock into the dock is possible for the largest tankers for four hours each side of high tides.

## CONSTRUCTING THE ENTRANCE LOCK

The work commenced with the construction of the entrance lock and an interesting stage of this work is illustrated in Fig. 2, which shows the stage reached in April, 1952, and the methods of attaining it. A cofferdam was first built out from the left bank of the river, immediately below the canal entrance locks, in order to enclose the working area for the construction of the entrance to the new lock. This cofferdam consisted of two lines of steel sheet piling set 18 ft. apart and driven into a rubble bank of 70 ft. base. In addition, a single line of piling was driven behind the left bank of the canal to seal off that side of the working area from possible seepage from the canal, so that excavation and concreting could be carried out under as dry conditions as possible.

## CLIMBING SHUTTERING

It will be seen from Fig. 2 that a form of climbing shuttering was used. Similar shuttering was also used for concreting the dock walls. The illustration also shows the temporary structure used to close off the lock at a point within the lock and immediately above the recess for the caisson required for closing the lock at its sea end. This temporary structure, or dam, is illustrated in Fig. 4, and consisted of an arch of interlocking Larssen No. 5 steel sheet piling further supported at the rear by three concrete ribs, themselves carried by a framework of girders built up from the floor of the lock.

On completing this temporary dam, the cofferdam was breached and the first caisson floated over on its side, after which it was righted and manœuvred into position in front of the temporary dam and sunk on to its sliding ways. This manœuvring into position called for careful handling, since the 106-ft. long caisson, while being edged into its recess in a lock 100 ft. wide, only allowed for a clearance of 2 in. After placing the caisson, the temporary dam was dismantled and removed, and the cofferdam (already breached) finally removed by dredging and a " back-acter " excavator.

## SLIDING CAISSONS

The three caissons, installed to divide the lock into two separate chambers, were made by Vickers-Armstrongs Limited, and brought to site by sea. Each caisson is of all-welded steel construction, displacing 1,700 tons and having a length of 106 ft. (transversely with the lock), a width of 23 ft. (longitudinally with the lock), and a height of 57 ft. Each is built to withstand a load of 5,000 tons due to the difference in water levels on either side.

Each caisson is divided horizontally into three parts by watertight decks. The upper portion is open at both ends and is a tidal waterway, the central portion houses an air chamber, two scuttling tanks and four trimming tanks, and the lower portion is a ballast chamber the water in which is controlled by two electrically-driven pumps capable of handling up to 200 tons of water an hour, so that the flotation weight may be adjusted to suit prevailing water levels and to keep friction on the sliding ways to a minimum.

Each caisson is fitted with mild-steel soleplates. Fig. 3, which is an illustration of one of the recesses for the caissons, shows the sliding ways on the floor of the lock, and the recess, with the winch-house controlling the movement of the caisson, in the background. The entrance to the recess is provided with grooves to take a sectional dam so that it may be closed off from the lock with its caisson in the recess, so enabling inspection and repair work to be carried out. All three recesses may be so closed off. The upper and lower recesses are 33 ft. wide, but the central one is 51 ft. wide and is thus a small dry dock into which any of the three caissons may be manœuvred for extensive repair should that ever be necessary.

## HYDRAULIC WINCH TRANSMISSION

Because the caissons have considerable inertia, control of their movements has to be precise and sensitive, particularly at the beginning and end of their traverse. In each winch house a 125-h.p. electric motor running at 490 r.p.m. drives a variable-delivery " V.S.G." pump supplying oil under pressure to a " V.S.G." rotary hydraulic motor which drives the 4-ft. diameter winch drums through gearing. The drums carry 6½-in. circumference steel wire ropes which, over various sheaves, haul the caissons into or out of their recesses.

Each drive to each caisson is duplicated. When using both drives, a hauling speed of 40 ft. a minute is obtained, i.e., a caisson may be moved from the fully open to the fully closed positions within three minutes. Using one drive only, through a change-speed box, these times are doubled. Control of the movement of a caisson is obtained by varying the inclination of the " tilting box " in the " V.S.G." pumps. A change of tilt regulates the amount of fluid discharged to the hydraulic motors and the direction in which the fluid circulates, and is accomplished by a 1-h.p. reversing pilot motor controlled by the operator through a hand lever. The direction of the applied tilt controls the direction of motion of the caisson, and the angle of tilt controls the speed of movement of the caisson.

In the event of a complete electrical breakdown a 3-cylinder oscillating hydraulic engine drawing from the hydraulic mains is provided for emergency use. Also connected to this engine is a 10-ton capstan which can be used either in an emergency or for warping the caissons about the lock.

## CONSTRUCTION OF THE DOCK

Excavation for the lock and dock required the removal of nearly 3½ million cubic yards of earth

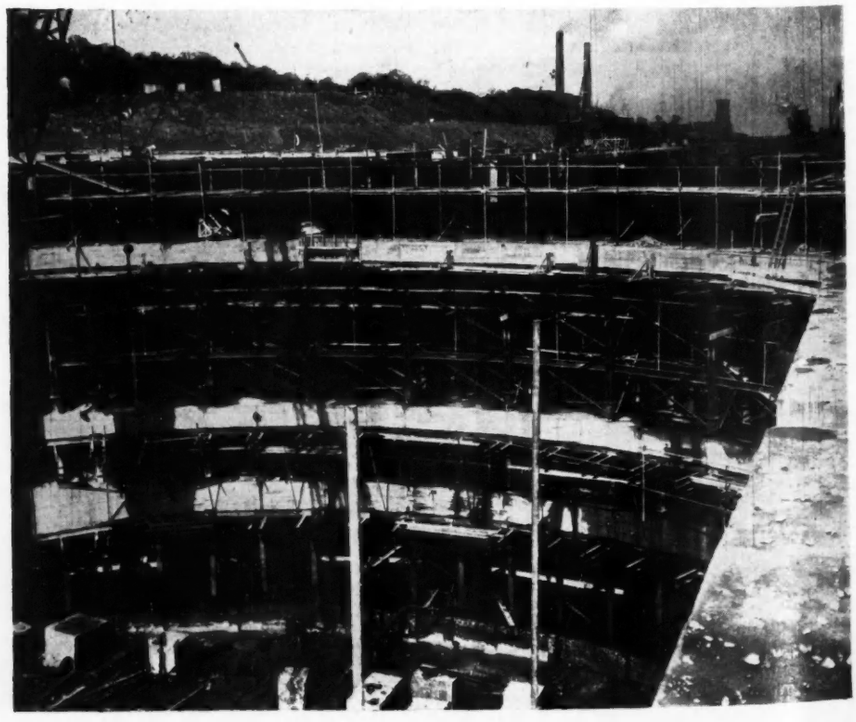

**Fig. 4 Temporary dam in the entrance lock, constructed to enable the seaward caisson to be floated into position.**

and sandstone, which was disposed of locally. Approximately half of the material excavated was sandstone. The maximum depth of the excavation was 80 ft. and all material was first removed by 2½-cub. yd. draglines and transferred to hoppers feeding 42-in. conveyor belts, which in turn fed to other conveyor belts. In all, 21 belts were installed, and of these, 17 were continuously in use. Each hopper was fed by two draglines, of which up to seven were kept at work. At the deposit grounds, the belts were tripped by rail-mounted Sutcliffe throw-off conveyors feeding to spreaders. The deposit grounds were afterwards trimmed, top-dressed and grassed, and it is difficult to appreciate that in the case of one ground, where there is now a rolling meadow, nearly 2 million cub. yd. of spoil were dumped into a depression. The excavating plant had a capacity of nearly 500 tons an hour and the work progressed at the rate of about 75,000 tons a week.

Some idea of the size of the excavation is given in Fig. 5, which also shows concreting in progress at the point where the lock joins the basin. Also clearly brought out are the steps left in the rock excavation and allowed for in the design of the dock wall for the first 10 ft. 6 in. of height, where the rock was found to be of sufficiently good quality.

Concreting was carried out in 4-ft. lifts and generally in sections 60 ft. in length. Approximately 70 per cent. of the concrete placed was pumped from a central batching plant, the remaining 30 per cent. being moved by a system of conveyor belts, elevators and chutes. The maximum time for a batch from the central plant to reach the most distant point of placing was seven minutes. The placing of concrete was completed in June, 1953, when over 350,000 cub. yd. had been placed. The finish of the work is to a high standard. Where a watertight joint between masonry and timber-faced control gates was required, the granite facing has been polished to a tolerance of 0·004 in.

**Fig. 5 This picture shows the excavation of the dock, and concreting work at the point where the lock joins the basin.**

## OIL DISCHARGING EQUIPMENT

The dock is provided with combined hose-handling cranes and pipeline bridges, built by John Smith (Keighley), Limited. One of these structures is illustrated in Fig. 6. Each has two 5-ton booms with a reach of 30 ft. 6 in. and centred 20 ft. apart, and each boom has its own raising, lowering and slewing mechanisms for handling the flexible pipes connecting the pipelines to the discharge points of the vessel discharging. Each boom has a total arc of slew of 195 deg. The flexible pipes are connected to rigid pipes carried across the dockside area by the over-bridge, and they, in turn, are connected to the discharging mains leading to the tank-farm and to Stanlow. The system is designed to expedite the handling of the flexible pipes connecting the ships to the shore pipelines, while, by taking the piping overhead to the mains, the dockside is kept clear of all obstructing piping and fire hazard is minimised. Provision has been made for extending each structure laterally, so that it may carry additional pipes and one or more booms to handle additional flexible connections, if required. In this discharging installation, pumping of the crude oil is done by the pumps of the vessels discharging.

## POWER-HOUSE

To provide the hydraulic power required to operate the sluices of the new lock and also to operate the gates and sluices of the existing locks at the entrance to the canal, a new power-house has been built. The building is a steel-framed structure 122 ft. in length and 46 ft. in width, with additional bays to house the transformers and switch-rooms. Two electrically-driven 280-h.p. pumps, each with a capacity of 330 gallons a minute at a pressure of 750 lb. per square inch, and automatically controlled from the hydraulic accumulator, supply the hydraulic mains. There is also a stand-by plant consisting of three 184-h.p. Diesel units, each with a capacity of 200 gallons a minute at a pressure of 750 lb. per square inch. Water for the fire-fighting installation is provided separately, and two electrically-driven two-stage pumps, each capable of delivering 1,000 gallons a minute at a pressure of 180 lb. per square inch, are installed for this purpose.

Adjacent to the power-house are two elevated reinforced-concrete water-storage tanks, one of which is supplied from the domestic water-supply mains and provides cooling water for the Diesel engines, while the other is supplied from the canal and provides water, after settling has taken place, to the hydraulic pressure system. To feed this second tank, water is taken from the canal through a 42-in. inlet pipe and passed to a well in the power-house, from where it is pumped to the tank by two electrically-driven 25-h.p. pumps, float-controlled from the draw-off chamber. Two stand-by electrically-driven 7½-h.p. pumps are also provided, power for which is supplied by two Diesel-driven generators.

Thus the power installation is self-sufficient in the event of an electrical failure. The Diesel stand-by plants can be brought into use not only to operate all the hydraulic equipment, but also to take over from the electrically-driven "V.S.G." pumps and motors.

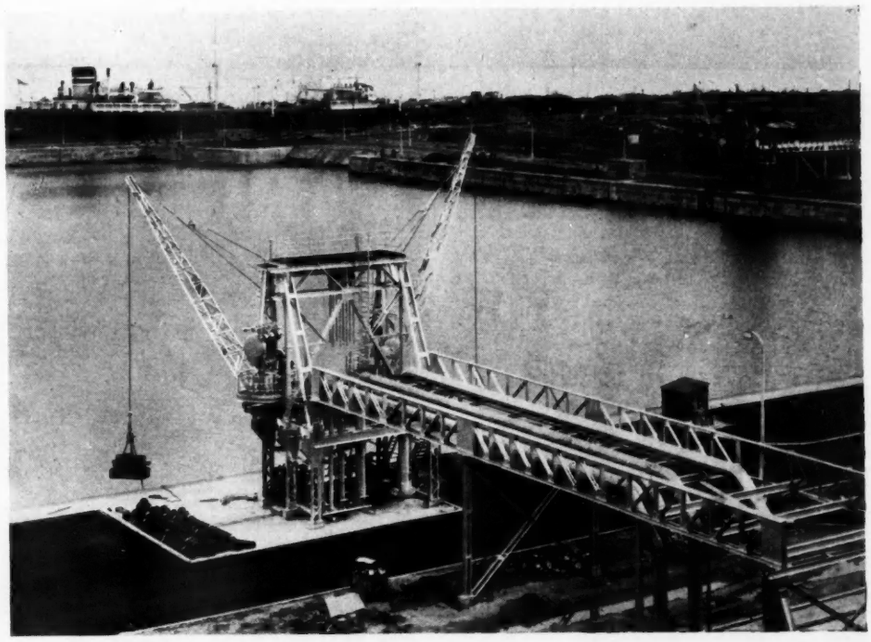

**Fig. 6 Oil is discharged from the tanker through the flexible pipes which are supported by special cranes shown here. It then passes through the pipes which are supported on a gantry to keep the dockside clear, and thence to a ring main and tank-farm.**

# CARBON DIOXIDE AS A MACHINING COOLANT

## CUTTING SPEEDS INCREASED

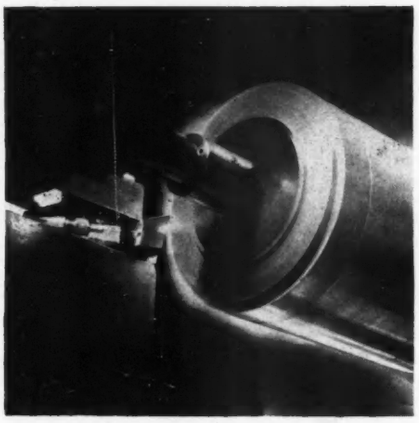

Fig. 1 Tool with side entry for $CO_2$ coolant starting a cut.

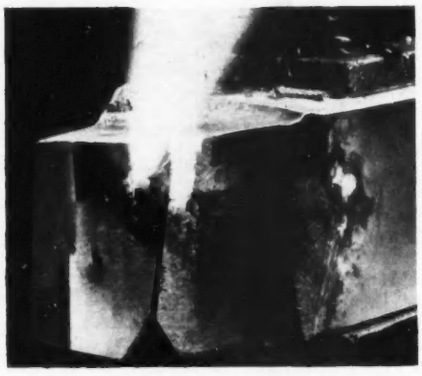

Fig. 2 $CO_2$ jet directed at cutting edge.

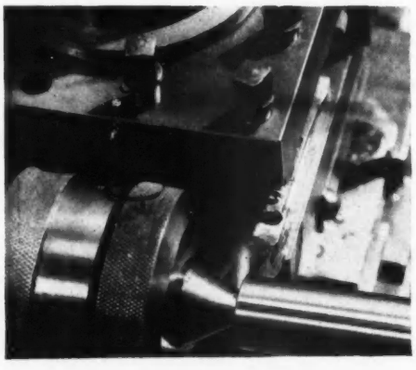

Fig. 3 Correct method of applying jet : it is not allowed to reach the chip.

With the increasing use of high-tensile steels and heat-resistant alloys, such as Nimonic and nickel-chromium-molybdenum steels, the life of cutting tools has been considerably reduced. This is partly due to the fact that most tool tips weaken rapidly with the increase in temperature that occurs when machining these materials; in the case of tungsten-carbide tips this weakening takes place at higher temperatures. To keep both the tool and workpiece cool, particularly when heavy cuts are being taken, copious quantities of coolant are usually directed on to the work area, the prime function of the coolant being to keep the temperature of the cutting edge as low as possible by keeping the surrounding metal so cool that the heat can be carried away by conduction through the shank of the tool. The rate of heat removal achieved by this method is not rapid. Furthermore, though the liquid may act as a lubricant, it is practically impossible for it to penetrate between the workpiece and the cutting edge or to provide lubrication along the actual line of cutting.

Liquid carbon dioxide has in recent years been applied to the problem of cooling cutting tools and the techniques that have been developed by the Carbon Dioxide Company, Limited, Abbey House, Baker-street, London, N.W.1, have resulted in its being introduced into the machine shops of a number of companies. One case of this was in the machining of extremely high-tensile steel shafts for gas turbines in the Rolls-Royce factory, East Kilbride.

Further development in the application of this method of cooling cutting tools is being continued by the central research department of the Distillers Company, Limited, Great Burgh, near Epsom, Surrey. Illustrations on this page show a carbon-dioxide cooling jet applied to turning, drilling, and tool grinding.

### NO COOLANT ON CHIP

The first three illustrations show a jet directed towards the leading edge of the tool in the correct manner, only the surplus coolant being allowed to reach the workpiece while none at all reaches the chip. In Fig. 4 the incorrect method is shown, an excessively large jet of liquid being allowed to expand to atmospheric pressure, producing a frost which it delivers on to the tool tip. Most of the potential cooling effect is wasted on the chip, thus preventing the required heat removal from the tool cutting edge. Figs. 1 and 3 illustrate the cleanliness of the operation, the clear view of the work afforded during turning and the absence of coolant above the cutting tool when the carbon-dioxide jet is properly applied. Fig. 9, opposite, illustrates an arrangement recently developed in which a reservoir of coolant is provided beneath the tool tip. Excess coolant discharges on to the face of the workpiece and assists in maintaining it at normal temperature, no coolant being allowed to reach the chip.

One of many possible arrangements that can be adopted for feeding the liquid along the shank to the reservoir is shown in Fig. 10. The shank of the tool is drilled and tapped to take the feed capillary, which incorporates a simple throttling valve. In practice, however, the capillary can be fed into the side of the shank as shown in Fig. 1. This arrangement enables a supply of coolant to be supplied to the tip when the tool is being reground. A V-groove cut along the bottom of the shank, as shown in Fig. 2, offers an alternative route by which the coolant capillary can be led to the tip, a hole being drilled at an angle from the lower face to come out directly beneath the cutting edge of the tip so that the coolant is directed where required.

### FOUR-FOLD INCREASE OF CUTTING SPEED

The application of carbon-dioxide cooling to machining enables the working temperature of the tools to be so reduced that the normal cutting speeds for certain high-tensile steels can be increased four-fold with a similar increase in the tool life. The inner and outer surfaces of turnings taken from En 25 and Nimonic 80 at cutting speeds of 700 and 130 surface ft. per minute, respectively, are shown in Fig. 7, magnified about 6 ×. The uniform plastic deformation of the swarf can be seen from its compressed corrugated surface. By operating at higher speeds the heat generated softens the metal being removed, while the cutting edge of the tool is kept cool and its strength retained. As a result, cratering of the tool tip is limited and secondary wear reduced, giving an improved surface finish.

In drilling operations the carbon-dioxide jet can be directed just above the point of entry of the drill so that solid carbon-dioxide adheres to the drill and the outside of the workpiece adjacent to the hole; this prevents any thermal distortion. As no lubricant is applied to the flutes of the drill in this method, to assist the removal of swarf, there are limits to its application.

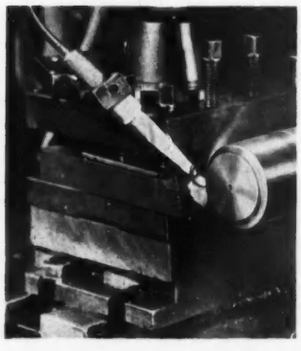

Fig. 4 Wrong method : the jet is spraying on top of tool and swarf.

Fig. 5 Drilling with $CO_2$ as coolant, jet directed above hole.

Fig. 6 Two jets are used in this grinding operation.

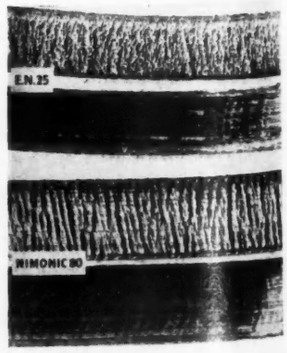


Fig. 7 Microphotograph of chips, showing uniform plastic deformation.

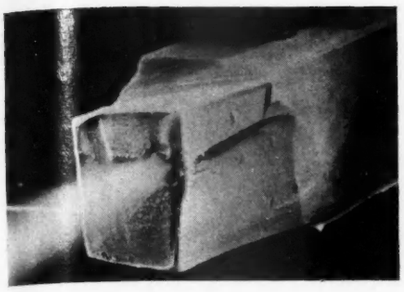

Fig. 9 Tool with the $CO_2$ orifice in the nose of the tool and the reservoir below the tip.

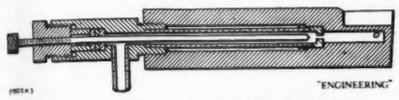


Fig. 10 Orifice valve in shank of tool.

Tests with high-tensile steels have, however, indicated that for holes of moderate depth high-drilling speeds are applicable. Samples of En 25 about 1 in. thick have been drilled at speeds of 700 r.p.m., with feeds of 0·04 and 0·08 in. per revolution, with a normal high-speed drill, and drill wear over 100 holes proved negligible.

The application for end-milling cutters is similar to drilling. Surface milling presents a more difficult problem and a system in which light oil is employed to weight the carbon-dioxide snow, to allow it to be projected and adhere to surfaces difficult to reach, is being tested.

Boring bars are considered relatively simple to equip and methods similar to those used for turning can be employed.

Separate jets may be used for grinding to maintain the tool tip at a normal temperature to prevent thermal cracking or weakening of the bond between the tip and shank, or the feed through the capillary already incorporated in the tool can be used.

### COOLING PRINCIPLE

Carbon-dioxide was first considered suitable for use as a coolant because it has a critical temperature of 88 deg. F., which meant that it could exist in the liquid state at ordinary room temperatures, and the latent heat of evaporation of the liquid would be available as a primary means of absorbing heat. Besides this, it was known that a concentration of up to 5 per cent. in the normal atmosphere would have no harmful physiological effects. It is also easily delivered to a machine in the form of a liquid under pressure, and its essential importance as a tool coolant is that with expansion to atmosphere, at the nozzle of the capillary, by flash evaporation, part of it is converted into a gas and the consequent reduction in temperature converts a further portion into a snow of solid carbon-dioxide which, at atmospheric pressure, exists at a temperature of — 109 deg. F., or — 141 deg. F. below freezing. Under atmospheric conditions the solid then sublimes directly into a gas, and for every pound of solid that is gasified 250 B.Th.U. of heat are removed from the surroundings.

The recommended method for delivering the liquid to jets or capillaries to guard against the formation of snow in either, due to premature expansion, is to use a pressure in the region of 750 to 1,000 lb. per square inch, at the same time cooling the liquid to a temperature in the region of 40 deg. F. on its way to the outlet. To give such a supply in the desired temperature range there are two principal systems available.

One of these is an eight-cylinder rack, of the type used for welding bottles, which incorporates a small electrically-operated refrigerator, and is designed to provide a supply of cooled liquid at a normal maximum output of 30 lb. per hour. This outfit is sufficient for works trials on one or two machines or as a permanent unit to deal with a number of small machines, such as may be expected in tool-room applications.

The rack manifolds are divided into two units, each carrying four cylinders having a capacity of approximately 20 lb. A convenient method of operation is to work from four cylinders on one manifold. Then, when these become empty, an indicator and an alarm system introduce a ninth auxiliary balance cylinder, which forms a permanent part of the rack. The reserve supply of liquid from this cylinder avoids interruption in delivery while the header valve on the four full cylinders is being opened, and those on the empty cylinders closed.

The rack system operates at a pressure corresponding to the combined temperatures of the four syphon cylinders coupled to the manifold, normally about 200 lb. per square inch higher than the corresponding vapour pressure of the cooled carbon dioxide as it is delivered from the rack. This pressure difference is therefore available to prevent premature expansion and to ensure that the carbon-dioxide does not form into a solid before it leaves the jet nozzle.

For production installations bulk storage tanks in two standard sizes are used. The larger size has a capacity of 6 tons of liquid carbon dioxide; the smaller unit a capacity of 1½ tons. Fig. 8 illustrates the larger standard tank. In these tanks liquid is maintained at a temperature of approximately — 5 deg. F. and at a pressure of approximately 290 lb. per square inch by a self-contained pressure-controlled refrigerant system. The tanks can be refilled from road tank wagons when required.

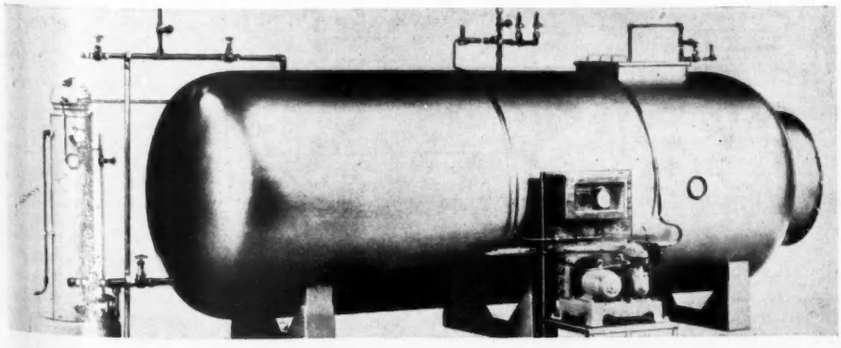

Fig. 8 Typical bulk storage tank for $CO_2$ coolant. A battery of $CO_2$ cylinders can be used where the rate of use is moderate.

## HYDRAULIC PUMP FOR 3,000 LB. PER SQ. IN.

### *Pressure Pulses Eliminated*

A high-capacity high-pressure pump, designated the Lockheed Mark 8 hydraulic pump, is now being produced by the Automotive Products Company, Limited, Leamington Spa. It has been introduced to meet the demand for increased hydraulic power in some of the larger aircraft.

The Mark 8 is virtually a duplex version of the Mark 7, which has seven radially-disposed plungers actuated by a common eccentric made integrally with the drive shaft. Thus the Mark 8 has 14 radially-disposed plungers, arranged in two plates of seven and actuated by a two-throw eccentric shaft. The rated maximum cruising speed of the Mark 8 pump is 3,300 r.p.m., and it follows, therefore, that there are no less than 770 pressure strokes per second, resulting in the hydraulic system being free from pressure pulses.

At 3,300 r.p.m., the rated minimum delivery is 1,418 cub. in. per minute at the maximum working pressure of 3,000 lb. per square inch, and under such operating conditions the horse-power absorbed is 12·9. This performance, however, is stated not to represent the final development of the pump, which, when the need arises, can still be increased by an appreciable amount. In common with the Mark 7 pump, the inlet porting of the Mark 8 is automatic. As a plunger moves radially inwards it uncovers an annular groove in the cylinder, connected to the inlet side of the pump. As the plunger moves radially outwards it first covers the groove, thereby closing off the inlet, and then forces the trapped fluid through a passage leading from the top of the cylinder, past a spring-loaded valve, into an annular passage in the high-pressure cover which is common to both plates and leads to the outlet connection.

The overall efficiency of the Mark 8 is in keeping with that of the Mark 7, and is stated to be high for the high pressure and speed at which the pump operates.

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## MATERIALS, METALLURGY AND MACHINING: ERRATUM

On page 8 of our January 1 issue, in the article entitled " Materials, Metallurgy and Machining," it was stated that the use of high-pressure cutting oils when cutting steel to S.11 specification resulted in cutting-life increases from 25 per cent. to 100 per cent. This should have read " from 25 to 100 times."

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## REFERENCE BLOCK FOR ULTRASONIC TESTING

The F.E.18 Ultrasonics Panel of the British Welding Research Association is considering the need for a standard, single-hole steel reference block for use in ultrasonic testing. Such blocks would have to be commercially available and should bear a mark showing that they are of approved design and quality. Individuals who are interested in this possibility are requested to communicate with the secretary of the F.E.18 Committee, British Welding Research Association, Abington Hall, Abington, Cambridge.

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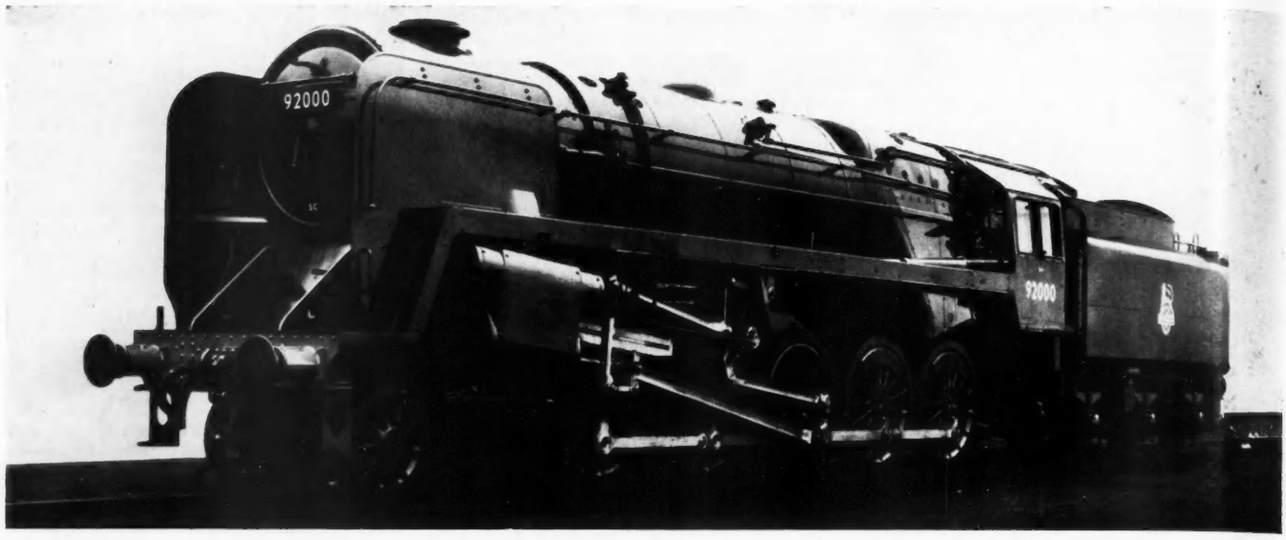
## MOTOR INDUSTRY SUMMER SCHOOL

The Eighth Annual Residential Summer School of the Institute of the Motor Industry is to be held at St. Catharine's College, Cambridge, from Saturday, August 21, to Saturday, August, 28. The course is open to all engaged in the motor industry, whether or not they are members of the Institute.




**This is the first of a series of new 2-10-0 heavy freight locomotives for British Railways the design of which includes a number of features not found on the previous standard locomotive classes.**

# HEAVY FREIGHT LOCOMOTIVE FOR BRITISH RAILWAYS

## DEPARTURES FROM STANDARD PRACTICE

A design of 2-10-0 heavy freight locomotive for British Railways – the first of which has been built recently at Crewe Works – incorporates several features not found on the standard locomotives. Indeed, the principle on which the wheels have been balanced has not previously been employed in this country. The long wheelbase and the close setting of the main frames have necessitated unusually ample cross-staying, and the ashpan, clearly, has presented some problems in design. The two Ross "pop" safety-valves are mounted on the boiler barrel instead of on the firebox, as is usual, and the tenders of these locomotives will have different water and coal capacities according to the region in which they are to work. The engines are intended principally for mineral traffic.

The design was carried out under the direction of Mr. R. A. Riddles, C.B.E., who at the time the design was prepared was the Railway Executive member for mechanical and electrical engineering. The parent office for the design is Brighton, though certain sections were designed at Derby, Doncaster and Swindon. The initial order comprises 20 locomotives, Nos. 92000 to 92019. The new design is in motive-power Class 9, and in spite of its size it has a fairly general route availability over large sections of British Railways. Most of the details of design are common with those of the previous standard types and the leading dimensions are as follow:—

| | |
|---|---|
| Cylinders (2), dia. and stroke .. | 20 in. by 28 in. |
| Wheels, coupled, dia. .. .. | 5 ft. |
| Wheels, tender, dia. .. .. | 3 ft. 3½ in. |
| Wheels, bogie, dia. .. .. | 3 ft. |
| Wheelbase, coupled .. .. | 21 ft. 8 in. |
| Heating surfaces: | |
| Tubes .. .. .. .. | 1,836 sq. ft. |
| Firebox .. .. .. | 179 sq. ft. |
| Total evaporative .. .. | 2,015 sq. ft. |
| Superheater .. .. .. | 535 sq. ft. |
| Grate area .. .. .. | 40·2 sq. ft. |
| Free flue area .. .. .. | 5·49 sq. ft. |
| Boiler pressure .. .. .. | 250 lb. per sq. in. |
| Tractive effort .. .. .. | 39,667 lb. |
| Adhesion factor .. .. .. | 4·38 |
| Minimum radius curve without gauge widening .. .. .. | 6 chains. |

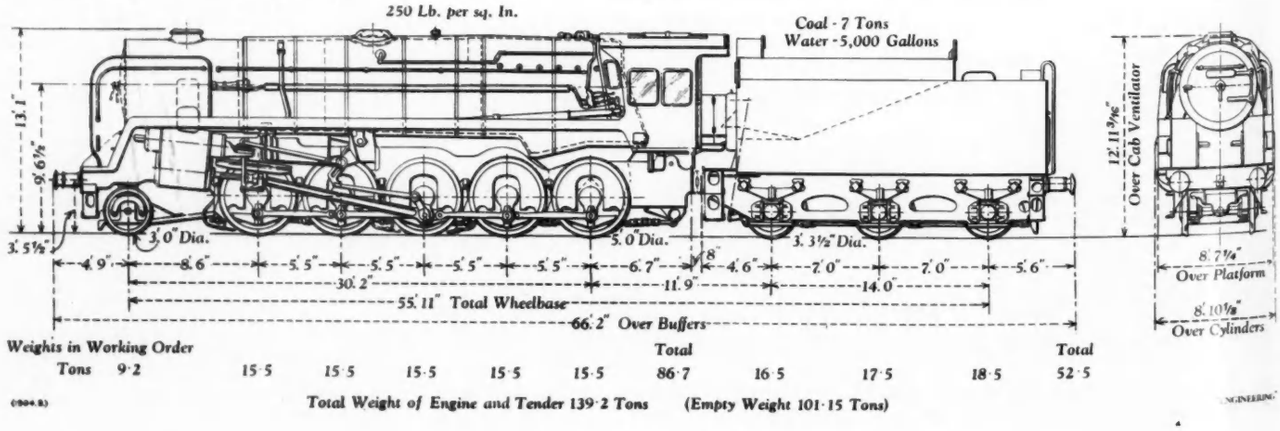
### A SPECIAL BOILER

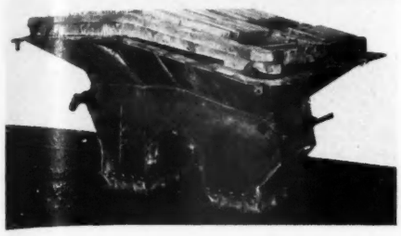
The boiler is similar in many respects to the wide-firebox types fitted to the Classes 6 and 7 Pacific designs. As the firebox is placed above the trailing pairs of coupled wheels (of as great a diameter as 5 ft.) it has not been possible to utilise an existing boiler. A new boiler has therefore been designed, incorporating pressings made from the same press blocks as for the Class 6, while the front tubeplate uses the same pressing as that for the Class 7. The firebox is, however, shallower than the 4-6-2 engines and, in addition, it has been necessary to employ a firegrate the rear portion of which is horizontal and the front portion sloping. The boiler shell is of high-tensile steel plate, the barrel consisting of two rings, the rear of which is tapered. The plate of the barrel rings is $\frac{13}{16}$ in. and $\frac{7}{8}$ in. thick, respectively, and the outside diameters are 5 ft. 9 in. at the front and 6 ft. 1 in. where the barrel meets the Belpaire firebox. There are 35 large flue tubes 5¼ in. in diameter outside and 7 s.w.g. thick, and 138 small tubes 2 in. in diameter outside and 11 s.w.g. thick. The length between the tubeplates is 15 ft. 3 in.

The firebox is 7 ft. 5½ in. long at the bottom, with a maximum outside width of 7 ft. 0⅛ in. The outer steel plate is ½ in. thick and the wrapper plate of the copper inner firebox is $\frac{5}{8}$ in. thick. The throat plate is sloping and a combustion chamber is provided.

The grate consists of 12 rocking sections, each fitted with 12 grid-type firebars. It is divided longitudinally so that the right and left sides can be rocked independently. The ashpan is of the self-emptying type and care has been taken to design the sides so as to give the steepest possible angle from the outside ledges of the wide firebox to the central hopper portion between the frames, to assist clearance of the ash.

The superheater consists of 35 of the Superheater Company's ball-joint elements, 1⅜ in. diameter outside and 9 s.w.g. thick, arranged in five rows of seven. The blast-pipe has a single exhaust nozzle 5⅜ in. in diameter, and four Cardew blower nozzles are incorporated in the cap.


250 Lb. per sq. In.
Coal - 7 Tons
Water - 5,000 Gallons
13' 1"
9' 6½"
3' 5½"
3' 0" Dia.
5' 0" Dia.
3' 3½" Dia.
12' 11 9/16" Over Cab Ventilator
8' 7¼" Over Platform
8' 10⅛" Over Cylinders
4' 9" 8' 6" 5' 5" 5' 5" 5' 5" 5' 5" 6' 7" 1' 8" 4' 6" 7' 0" 7' 0" 5' 6"
30' 2" 11' 9" 14' 0"
55' 11" Total Wheelbase
66' 2" Over Buffers
Weights in Working Order
Tons 9·2 15·5 15·5 15·5 15·5 15·5 Total 86·7 16·5 17·5 18·5 Total 52·5
Total Weight of Engine and Tender 139·2 Tons (Empty Weight 101·15 Tons)



**The design of the ashpan – shown here with the grate in position – was circumscribed by the proximity of the rear coupled wheels (the axle of which passes through the arched way) and by the small width between the frames.**

### STIFFENING OF THE MAIN FRAMES

The frames are particularly rigid. They consist of 1¼-in. frame plates spaced by vertical stretchers at intervals throughout the length. Horizontal plate stretchers extend rearwards from the saddle, continuously to the ashpan at a level just above the horn spaces, and at the bottom of the frame rigid cross-stretchers are formed integrally with the vertical stretchers. The frame plates are located in the planes of the centre-lines of the axleboxes, and the hornblocks, which are therefore symmetrical and of horseshoe form, are welded in, and are provided with manganese-steel liners. The bottom edges of the frameplates are stiffened by steel castings of inverted-T form, which fulfil two additional functions. One is that they are cast integrally with the spring-hanger brackets and the other that they contain the registers for the hornstays. These castings are riveted to the frame using the rivets which engage the lower cross-stretchers. When the hornstays are in position the frame plates have virtually a continuous bottom flange. Between the fourth and fifth pairs of coupled wheels, and over the horn gap for the latter, the frame has to be cut away to clear the firebox, but to retain adequate strength as a beam stiffening plates are riveted to each side of the frame plates.

The two cylinders are steel castings with cast-iron liners to the steamchest and cylinder barrel. The cylinder diameter is 20 in. and the stroke 28 in. The piston valves have a nominal diameter of 11 in. and are driven by Walschaerts valve gear giving a maximum travel in full forward gear (78 per cent. cut-off) of 7⅞ in. with a steam lap of 1 11/16 in. and a lead of ¼ in. The piston head on the first locomotives to be turned out will be of the box type made as a steel casting and fitted with two rings and a bronze spring-loaded slipper. Later engines will have a light forged-steel piston head flash-butt welded to the piston rod.

### REDUCED "WHEEL" HAMMER-BLOW

The wheel balancing follows a principle not previously employed in this country. The rotating masses are fully balanced in the normal way but the reciprocating masses are statically balanced to the equivalent of 40 per cent., by placing lead weights in the coupled wheels in the same phase on both sides of the engine. This leaves the fore-and-aft balance of the locomotive the same as if the normal procedure were followed, namely, of making the reciprocating-mass balance coincide with the rotating-mass balance. There remains an unbalanced couple but this is no larger than that tolerated in 3-cylinder locomotives without reciprocating balance. On the credit side the new system reduces the "wheel" hammer-blow (but not the "axle" hammer-blow) and also saves approximately 2 cwts. of balance weight.

Various arrangements of tender will be provided to suit the particular operating requirements of the region on which the batches of locomotives are to work. Some regions require a high water capacity in relation to coal, particularly for routes where water troughs are infrequent or wholly absent, whereas elsewhere, for long-distance freight work, where troughs are provided at frequent intervals, high coal capacity becomes the important factor. A new design of tender has therefore been produced, in which the coal bunker extends the full width of the water tank. The first batch of tenders, however, will be of the existing pattern.

## *Labour Notes*

# SECRET BALLOTS IN INDUSTRIAL DISPUTES

Recent strikes and threats of strikes, and the obvious disinclination of employees, in some instances, to participate in them, have brought forth suggestions in some directions that the time has come when the public, and the trade unionists themselves, should be protected against strikes thrust upon reluctant workpeople by trade-union executive bodies.

One such proposal, which has found many supporters in the past, is that no strike should be legally recognised unless it has been preceded by a secret ballot of the members of the union concerned, in which a given proportion of members must vote, and in which a stated percentage of these voters must approve of the action to be taken.

Although some unions, by their rules, require the previous approval by their memberships of any decision to take strike action, there are several arguments against trying to enforce secret strike ballots by legislative means. To begin with, it is very unlikely that such a step would meet with the approval, or anything approaching it, of the trade-union movement, and on the goodwill of that movement the recovery and economic prosperity of the country in no small measure depend.

It is contended that the enforcement of the secret ballot would lead to an increase in unofficial strikes, thereby undermining industrial conciliation machinery, and tend to weaken the influence of trade-union leaders as a whole, most of whom are fully aware of the dangers of strike action. There would be, it is felt, many demands from extremist elements, upon the slenderest pretexts, for the taking of secret ballots, and this would have a bad effect on union stability.

### GOVERNMENT REACTION

That the Government is not favourably inclined towards proposals for the enforcement of secret ballots was apparent from their attitude to a Parliamentary question asked on January 19, when the Prime Minister stated that he would not introduce legislation to make strikes illegal until such time as secret ballots of workpeople, under Government auspices, had been taken. He said that there was no intention of departing from the established tradition in this country, under which the trade-union movement was left to manage its own affairs. He was advised that the disadvantages of the proposal would greatly outweigh any advantages.

To a supplementary question as to whether it would not be "a good thing" if employees were able to express their opinions without fear of victimisation and dictation by their own leaders, no answer was returned.

### OVERTIME BAN BY LONDON STEVEDORES

As from last Monday, stevedores at the London docks have declined to work overtime, as a means of protesting against the refusal of the port employers to agree to place all overtime on a voluntary basis. This issue has been raised on previous occasions, and, in particular, during the 1952 dock dispute. The working of overtime has been regarded over the years by employers and workpeople alike as being essential to the smooth running of the dock industry, and, according to the terms of the dock labour scheme, which was enacted with the approval of both sides, employees must be prepared to accept reasonable overtime.

This has been regarded as the amount of overtime which is reasonable in the circumstances of each particular case. The men, apparently, wish overtime to be regarded as unreasonable if they do not wish to perform it.

Another cause of difficulty at the docks is the men's demand that the employers should insure them against accidents, and they have threatened to strike if this request is not met. Only the National Amalgamated Stevedores and Dockers are involved in these disputes. Some dockers belong to this union, but most are members of the Transport and General Workers' Union, which is not concerned.

### ELECTRICIANS' STRIKE

It was announced towards the end of last week, that the week-long strike of electrical-contracting employees in the London area, which commenced last Monday, would be followed by similar action in other large cities. Meanwhile, token strikes by members of the Electrical Trades Union at steelworks, power stations and atomic-energy establishments are to continue. Mr. W. C. Stevens, the union's general secretary, confirmed last Saturday that some 1,800 men were taking part in these scattered demonstrations.

On their side, the employers, the National Federated Electrical Association, have repeatedly offered to refer the dispute to arbitration.

### SELECTION OF PERSONNEL

The engaging of semi-skilled or unskilled workpeople, and their training for the requirements of a particular business, frequently prove expensive in time and money to the firm concerned. Should the new employees leave or be discharged soon afterwards, as often happens if they have been badly selected, the time and money spent in this way are wasted. For this and other reasons, it is becoming increasingly recognised that the selection of the right employees is a matter requiring much care, tact and experience on the part of managements.

In an endeavour to render assistance to heads of departments, personnel officers and foremen on this difficult industrial problem, the Ministry of Labour and National Service has issued the third booklet in its "true story" series. This is entitled *Selecting the Man for the Job*, and takes the form of a report of a round-table discussion between the managing director of a small business, the personnel officer of a large organisation, a works foreman, and a psychologist who specialises in selection methods. The conclusions reached by these four persons in different spheres of industrial life are put forward as the guiding principles to be borne in mind in the selection of new staff.

After discussing some of the problems associated with personnel selection in large, medium-sized and small firms, respectively, the advantages of systematic selection methods, and the wastages they avoid, are explained. The various means used by employers in the engaging of newcomers are considered and reference is made, in some detail, to the seven-point plan of the National Institute of Industrial Psychology. Among other subjects, the booklet deals with the reception of applicants for work, suggested procedure at interviews, the use of forms, and methods of testing applicants as to their suitability.

The booklet, which contains a number of small illustrations, has been prepared in collaboration with the Central Office of Information. Copies may be obtained, free of charge, from the Director of Public Relations, Ministry of Labour and National Service, 8 St. James's-square, London, S.W.1.

# NOTICES OF MEETINGS

### British Institution of Radio Engineers

GLASGOW
"Electronics in Film Making," by W. D. Kemp and B. R. Greenhead. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Feb. 4, 7 p.m.

LIVERPOOL
"Micro-Wave Test Gear," by J. Bilbrough. Merseyside Section. Electricity Service Centre, Whitechapel, Liverpool. Thurs., Feb. 4, 7 p.m.

MANCHESTER
"Police Radio: Its Past, Present and Future Possibilities," by I. Auchterlonie. North-Western Section. College of Technology, Manchester, 1. Thurs., Feb. 4, 7 p.m.

### Chemical Society

LONDON
"Kinetics and Mechanism of Inorganic Reactions in Solution: A Survey of Recent Work." A Symposium, by Dr. J. H. Baxendale, Professor F. S. Dainton and others. Thurs., Feb. 4, 2.30 p.m. and 7.30 p.m.

BRISTOL
"The Radio-Chemical Centre at Amersham," by Dr. W. P. Grove. The University, Bristol. Thurs., Feb. 4, 7 p.m.

### Cleveland Institution of Engineers

MIDDLESBROUGH
"The Operation of Soaking Pits," by J. Dodd. Cleveland Scientific and Technical Institution, Corporation-road, Middlesbrough. Mon., Feb. 1, 6.30 p.m.

### Incorporated Plant Engineers

LONDON
Open Discussion Meeting. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Feb. 2, 7 p.m.

EDINBURGH
"Efficiency of a Modern Steam Plant," by H. E. Partridge. 25 Charlotte-square, Edinburgh. Tues., Feb. 2, 7 p.m.

PETERBOROUGH
"Feed-Water Treatment," by Hector Taylor. Eastern Gas Board's Offices, Church-street, Peterborough. Thurs., Feb. 4, 7.30 p.m.

SOUTHAMPTON
"Heat Pumps," by Oliver Lyle. Polygon Hotel, Southampton. Wed., Feb. 3, 7.30 p.m.

### Institute of Fuel

CARDIFF
"The Railways and Coal," by R. G. Jarvis. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Feb. 5, 6 p.m.

SHEFFIELD
"Fuel Oil and Oil Firing," by G. J. Gollin. Yorkshire Section. The University, Sheffield. Wed., Feb. 3, 6.30 p.m.

### Institute of Marine Engineers

GRAVESEND
"Gas Turbines," by J. Hodge. Junior Lecture. Gravesend Technical College, Gravesend. Wed., Feb. 3, 7 p.m.

LIVERPOOL
"Marine Diesel Engines," by A. G. Arnold. Junior Lecture. Riversdale Technical College, Liverpool. Wed., Feb. 3, 7 p.m.

### Institute of Metals

LONDON
"Germanium and Silicon," by R. W. Douglas. London Local Section. Thurs., Feb. 4, 6.30 p.m.

BIRMINGHAM
"The Fracture of Steel," by J. E. Russell. James Watt Memorial Institute, Birmingham. Thurs., Feb. 4, 6.30 p.m.

### Institute of Welding

LONDON
"Avoiding Fatigue in Welded Structures," by Dr. R. Weck. North London Branch. 26 Portland-place, W.1. Thurs., Feb. 4, 7.30 p.m.

### Institution of Civil Engineers

LONDON
"Site Exploration for Maritime and River Works," by M. J. Tomlinson. Maritime Engineering Division. Tues., Feb. 2, 5.30 p.m.

MANCHESTER
"Load Factor Design in Reinforced Concrete," by Dr. F. G. Thomas. North-Western Association. College of Technology, Manchester. Tues., Feb. 2, 6.45 p.m.

### Institution of Electrical Engineers

LONDON
"The Manchester-Kirk o'Shotts Television-Radio Relay System," by G. Dawson and others. Ordinary Meeting. Thurs., Feb. 4, 5.30 p.m.

"Measurement of the Winding Resistances of 132-kV Power Transformer in Service," by Dr. K. J. R. Wilkinson and J. D. Harmer. Joint Meeting of Measurements and Supply Sections. Tues., Feb. 2, 5.30 p.m.

"An Outline of Television Systems." Students' Lecture, by Dr. R. L. Smith-Rose. London Students' Section. Mon., Feb. 1, 6.30 p.m.

BIRMINGHAM
"A Recent Application of Diesel-Electric Propulsion," by P. W. R. Gatliff; "Some Aspects of the French Distribution System," by K. Shaw; and "The Production and Testing of Transistors," by J. Hughes. South Midland Centre. James Watt Memorial Institute, Birmingham. Mon., Feb. 1, 6 p.m.

CAMBRIDGE
"Industrial Application of Radio-Active Isotopes," by S. Jefferson. East Midland Centre. Cambridgeshire Technical College, Cambridge. Tues., Feb. 2, 6.30 p.m.

CARDIFF
"Electro-Heat and Prosperity." Faraday Lecture, by O. W. Humphreys. Western Centre. Sophia Gardens Pavilion, Cardiff. Mon., Feb. 1, 6.30 p.m.

CHESTER
"Faster Than Thought," by Dr. B. V. Bowden. Joint Meeting of Mersey and North Wales Centre and North-Western Centre. Town Hall, Chester. Mon., Feb. 1, 6.30 p.m.

DERBY
"New Lamps: New Uses and New Lighting Techniques," by R. V. Mills. East Midland Centre. Electricity Service Centre, Derby. Tues., Feb. 2, 6.30 p.m.

LEEDS
"The Testing and Specification of Bushings in Relation to Service Conditions," by H. Barker and H. Davies. North Midland Centre. Offices of the Yorkshire Division, B.E.A., 1 Whitehall-road, Leeds. Tues., Feb. 2, 6.30 p.m.

MANCHESTER
"Continuity of Electricity Supply," by H. Leybura. North-Western Centre. Engineers' Club, Manchester. Tues., Feb. 2, 6.15 p.m.

PORTSMOUTH
"Network Analysers for Alternating-Current Systems," by A. W. Hales. Southern Centre. Municipal College, Portsmouth. Wed., Feb. 3, 6.30 p.m.

### Institution of Engineering Inspection

LONDON
"Copper and Its Applications, with Reference to the Activities of the Copper Development Association," by G. W. Preston. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Thurs., Feb. 4, 7 p.m.

BIRMINGHAM
"The Organisation of Inspection on the Lines of Statistical Quality Control," by J. Forster-Cooper. Birmingham Chamber of Commerce, 95, New-street, Birmingham. Wed., Feb. 3, 7.30 p.m.

BRISTOL
"Practical Applications of Interference of Light," by C. B. Daish. South-Western Branch. Grand Hotel, Bristol. Tues., Feb. 2, 7.30 p.m.

COVENTRY
"Quality Control in the United States," by S. W. Nixon. Coventry Technical College, Coventry. Tues., Feb. 2, 7.30 p.m.

### Institution of Locomotive Engineers

LONDON
Film Evening. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., Feb. 4, 5.30 p.m.

### Institution of Mechanical Engineers

COVENTRY
Chairman's Address, by Leonard Griffiths. Coventry A.D. Centre. Craven Arms Hotel, High-street, Coventry. Tues., Feb. 2, 7.15 p.m.

MAIDSTONE
"History of Patents," by R. E. Tree. Southern Branch. Maidstone Technical College, Maidstone. Wed., Feb. 3, 7 p.m.

MANCHESTER
"Steelwork Engineering, with Reference to Continuous Strip Mills," by Lieut.-Col. R. L. Willott. North-Western Branch. Engineers' Club, Manchester. Thurs., Feb. 4, 6.45 p.m.

NEWCASTLE-UPON-TYNE
"High-Temperature Turbine Machinery for Marine Propulsion," by Dr. T. W. F. Brown. North-Eastern Branch. Neville Hall, Newcastle-upon-Tyne. Mon., Feb. 1, 6 p.m.

### Institution of Production Engineers

BRIGHTON
"Mechanical Handling Techniques," by J. Bain. London Section. Old Ship Hotel, Brighton. Thurs., Feb. 4, 7 p.m.

NOTTINGHAM
"Researches in Deep Drawing," by Professor W. H. Swift. Victoria Station Hotel, Milton-street, Nottingham. Wed., Feb. 3, 7 p.m.

PETERBOROUGH
"Design for Welding." Discussion. Campbell Hotel, Bridge-street, Peterborough. Tues., Feb. 2, 7.30 p.m.

WOLVERHAMPTON
"Electronics in Production Engineering," by D. F. Whatley. Wolverhampton and Staffordshire Technical College, Wolverhampton. Wed., Feb. 3, 7.15 p.m.

### Institution of the Rubber Industry

LIVERPOOL
"Preparation and Use of Reclaim," by W. E. Stafford and R. A. Wright. Merseyside Section. Electricity Supply Showrooms, Whitechapel, Liverpool. Mon., Feb. 1, 7 p.m.

NEWCASTLE-UPON-TYNE
"Quality Control," by G. G. Lilley. North-Eastern Section. Neville Hall, Newcastle-upon-Tyne. Mon., Feb. 1, 7 p.m.

### Institution of Sanitary Engineers

LONDON
Code of Practice: "Soil and Waste Pipes Above Ground." Discussion. Caxton Hall, Westminster, S.W.1. Tues. Feb. 2, 6 p.m.

### Institution of Structural Engineers

BRISTOL
"The Industrial Architect and Engineer," by J. E. Collins. Western Counties Branch. The University, Bristol. Fri., Feb. 5, 6 p.m.

MIDDLESBROUGH and NEWCASTLE-UPON-TYNE
"Prestressed Concrete in Civil-Engineering Works," by A. J. Harris. Northern Counties Branch. Cleveland Scientific and Technical Institute, Middlesbrough, Tues., Feb. 2, 6.30 p.m.; and Neville Hall, Newcastle-upon-Tyne, Wed., Feb. 3, 6.30 p.m.

### Junior Institution of Engineers

LONDON
Film Evening. Townsend House, Greycoat-place, S.W.1. Fri., Feb. 5, 7 p.m.

BIRMINGHAM
"Sintered Component Manufacture," by B. H. Swann. Midland Section. James Watt Memorial Institute, Birmingham. Wed., Feb. 3, 7 p.m.

### Manchester Association of Engineers

MANCHESTER
"Design and Construction of Large Aircraft," by H. Rogerson. Engineers' Club, Manchester. Fri., Feb. 5, 6.45 p.m.

### Reinforced Concrete Association

LIVERPOOL and MANCHESTER
"Load-Factor Design in Reinforced Concrete," by Dr. F. G. Thomas. North-Western Branch. 24 Dale-street, Liverpool. Wed., Feb. 3, 6.30 p.m.; and College of Technology, Manchester. Tues., Feb. 2, 6.45 p.m.

### Royal Aeronautical Society

LONDON
"Air Intake Efficiency," by F. B. Greatrex. Section Lecture. 4 Hamilton-place, W.1. Thurs., Feb. 4, 7 p.m.

### Royal Society of Arts

LONDON
"Evolution of Public-Health Engineering," by F. E. Bruce. Wed., Feb. 3, 2.30 p.m.

### Royal United Service Institution

LONDON
"Operational Applications for Water-Based Aircraft," by Group Captain G. W. Williamson. Wed., Feb. 3, 3 p.m.

### Société des Ingénieurs Civils de France (British Section)

LONDON
"Fifty Years of Welding in France," by Dr. M. Lebrun. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Feb. 3, 6 p.m.

### Society of Engineers

LONDON
Presidential Address, by W. R. Howard. Geological Society, Burlington House, Piccadilly, W.1. Mon., Feb. 1, 5.30 p.m.

**The address of the headquarters of each Institution is given in the following list. Meetings held in the headquarters town are held at this address unless otherwise stated.** Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

British Institution of Radio Engineers, 9 Bedford-square, London W.C.1.
Chemical Society, Burlington House, Piccadilly, London, W.1.
Cleveland Institution of Engineers, 5 Ambleside-road, Normanby, Middlesbrough.
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham.
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1.
Institute of Marine Engineers, 85 The Minories, London, E.C.3.
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1.
Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1.
Institution of Civil Engineers, Great George-street, London, S.W.1.
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2.
Institution of Engineering Inspection, 28 Victoria-street, London, S.W.1.
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1.
Institution of Mechanical Engineers, 1 Birdcage-Walk, St. James's Park, London, S.W.1.
Institution of Production Engineers, 36 Portman-square, London, W.1.
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1.
Institution of Sanitary Engineers, 118 Victoria-street, London, S.W.1.
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1.
Junior Institution of Engineers, 39 Victoria-street, London S.W.1.
Manchester Association of Engineers, 20 Booth-street, Manchester, 2.
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1.
Royal Aeronautical Society, 4 Hamilton-place, London, W.1.
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2.
Royal United Service Institution, Whitehall, London, S.W.1.
Société des Ingénieurs Civils de France (British Section), 82 Victoria-street London, S.W.1.
Society of Engineers, 17 Victoria-street, London, S.W.1.